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The Preservation of Records, Knowledge and Memory (RK&M) Across Generations: Improving Our Understanding

RK&M Workshop Proceedings
12–13 September 2012
Issy-les-Moulineaux, France

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Radioactive Waste Management Committee

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12-13 September 2012
NEA Headquarters, Issy-les-Moulineaux (France)

Please note that this document is also available as a report electronically on the NEA website: www.oecd-nea.org/rwm/rkm.

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Radioactive Waste Management

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NUCLEAR ENERGY AGENCY
ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Foreword

The Second Preservation of Records, Knowledge and Memory Across Generations Workshop was held 12-13 October 2012 in Issy-les-Moulineaux, France, as part of the homonymous project under the aegis of the NEA Radioactive Waste Management Committee. There were 50 participants from 11 countries representing national governments, universities, waste management agencies, safety authorities, community groups, and specialists in both the technical and social sciences. Three international organisations were also represented.

The overarching goal of the workshop was to improve our understanding of the questions pertaining to the project, and the wider culture of RK&M preservation. The workshop encouraged the discussion of experience and research from project members, the wider field of radioactive waste management, and beyond that field into academia, archiving, art, and others. The underlying assumptions of the project were reconsidered and the availability of different mechanisms and models for RK&M preservation were discussed. The fundamental need for social engagement with RK&M Preservation ran through all of the themes discussed.

On the first day there were three themes – 'Why Preserve RK&M', 'Conceptualising RK&M Loss', and 'How to Preserve RK&M'. 'Why Preserve RK&M' looked at the "safety story" from the perspective of regulation, monitoring and the role of safeguards. 'Conceptualising RK&M Loss' looked at loss and recovery and 'How to Preserve RK&M' looked at mechanisms for RK&M recovery in the short and medium term. There was also a project update on the progress of the bibliography analysis.

On day two, the theme of 'How to Preserve RK&M' continued, looking at the medium and long term, archives, and the pragmatic organisation of an RK&M programme. 'What to Preserve' considered the minimal set of records which should be preserved.

The presentations included ongoing project studies, questionnaire analysis, academic critiques, case studies on plans for future programmes, current practice, consultant studies commissioned for the project, reports on areas for further research, and an introduction to an art exhibition inspired by the need to preserve knowledge and memory.

In total 31 talks were delivered, each followed by a Q&A session. 8 plenary discussions also took place.

The present document provides a synthesis of all the workshop presentations and accounts of discussions that were held. It also provides a list of the main observations garnered from the workshop for future work within the RK&M project.

Please note that numbering in the document is consistent with the workshop agenda.

Acknowledgments

The RK&M project wishes to thank external speakers who greatly contributed to the success of the event.

This document was produced by Helen Gordon-Smith (OECD NEA), Jantine Schröder (SCK•CEN), and Claudio Pescatore (OECD NEA).

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Introduction and organisation of this document

This Introduction has been adapted from the presentation given at the start of the workshop by Claudio Pescatore.

The OECD NEA Project on the "Preservation of Records, Knowledge and Memory (RK&M) across Generations" was launched officially by the NEA Radioactive Waste Management Committee in March 2011 in the context of geological disposal of radioactive waste.

There are representatives from 30 organisations in 11 countries, plus the IAEA, and support from the European Commission. Most organizations provide a financial or in-kind contribution to the running of the project.

There is a project website - http://www.oecd-nea.org/rwm/rkm/ . This provides access to the Vision document, the Collective Statement on Status and Needs in RK&M(2011), the Proceedings of the first workshop (held in October 2011), and the progress report for 2011.

There are also two living documents, which will be updated as the project develops:

1. A Project Bibliography.

   A preliminary analysis has been conducted. An updated, more consistent bibliography will be created and a new analysis conducted.

2. A Project Glossary.

A report on Examples of Memory Loss and Recovery will be added to the website, as well as various surveys conducted throughout the project.

Five surveys were reported during this workshop on the following topics: connection to safety case, experience in decommissioning, responding to EU requirements, use of national archives, and regulatory requirements.

In preparing this workshop

We began arranging the agenda for this workshop by looking at the main observations from the October 2011 Workshop and the minutes from the April 2012 Project Meeting. These, accompanied (in brackets) by the Workshop items which examined them, were as follows:

- The role and functioning of archives vis-à-vis RK&M preservation in the context of radioactive waste management needs be explored further (*A. Claudel, S. Tucker, I. Hill, J. Springer*).

- RK&M loss and misuse: we have an initial set of data and analysis. We need to verify the completeness and the sufficiency of the information collected to date. (*M. Buser, I. Rehak, J-G Nokhamzon*)

- The relationship between regulation, licensing and RK&M preservation for the long-term needs to be better understood. (*H. Gordon-Smith, G. Kwong, L. Nachmilner*)

- The relationship between RK&M preservation and safeguards needs further clarification. (*C. Pescatore, G. Kwong*)

- How we can 'mothball' knowledge and create a reservoir of tacit knowledge for a later revival of the knowledge on a larger scale? (*W. Ernst, J. Day, M. Martell, M. Jensen*)

- Adding cultural (historical) value to the facility and creating the conditions for continued value to the community would contribute to memory keeping. (*C. Holtorf, A. van Luik, J-N Dumont, C. Massart*)

- Standardization of messages may be useful for records to be kept for very long time and for markers. This area is best addressed through international cooperation, and should be developed further. (*S. Wisbey, T. Schneider, J. Schröder, A. Rose, A. Ray*)

- Requirement management systems that allow for data not only to be kept, but also to be culled, are needed. (*J.-P. Boyazis, J. Day*)

- There should be an attitude of openness towards the future. We are on stronger ground if we privilege an attitude towards information that allows people to protect themselves. (*A. van Luik, D. Shafer*)

- Operators and regulators would benefit from a review of outstanding "legal" requirements in this area, and from a clear national or international position. (*C. Mays, H. Gordon-Smith*)

- Pragmatic issues in establishing and running an RK&M programme need to be addressed. (*J-N Dumont, R. Patterson*)

An overall observation made during the project meeting in April 2012 was that we are still scoping the field, but we are being systematic and innovative.

Sessions

Consideration of these areas led to commissioning studies by consultants, drawing up surveys for the project group and other groups, and inviting organisations new to the project to come to the workshop to discuss their experiences.

The Workshop was organised into nine sessions, which fit into four different themes (in italics).

1. Introduction

Why Preserve RK&M

2. The Safety Story

Conceptualising RK&M Loss

3. RK&M, Loss, and Recovery

How to Preserve RK&M – Part 1

4. Mechanisms for RK&M Preservation and Recovery, in the Short Term

5. Mechanisms for RK&M Preservation and Recovery, in the Medium Term

6. Mechanisms for RK&M Preservation and Recovery, in the LongTerm

7. Archives: National, Transnational and Supranational

What to Preserve

8. Minimum Set of Records

How to Preserve RK&M – Part 2

9. Pragmatic Organisation of RK&M Preservation: Cost, Funding, Human Resources.

These sessions were developed to provide a coherent intellectual framework to the Workshop, in order to add thematic depth to the disparate range of topics under consideration.

The project's key questions as addressed in the vision document ('What, where, when, why, how and who') where addressed indirectly throughout all sessions , but not used as organising principles for

the workshop sessions, as they were found to be limited in their ability to separate the different strands of thought and create space for creative discussion.

The workshop sessions aimed to open out the discussion to new ideas and new organisations within their own arena, and thus also to illuminate and inspire the discussions in the other sessions.

Speakers, Consultants and Guests

The project has focused on drawing in a wide range of experience and input. At this workshop, ten organisations from outside of the project, eight of which were from outside the nuclear industry, were invited to participate.

Invited Speakers

- John A. Day, Sellafield, UK
- Wolfgang Ernst, Humboldt-Universität zu Berlin
- Cornelius Holtorf, Linnaeus University
- Thomas Kaiserfeld, Lund University
- Alain Rey, Arnano
- Alexander Rose, Long Now Foundation
- Thierry Schneider, CEPN
- David S. Shafer, USDOE-Legacy Management
- Joie Springer , UNESCO
- Simon Tucker, National Nuclear Archive, NDA, UK

Additionally, the Secretariat has, on behalf of the project, commissioned a number of studies from consultants, and invited other consultants to attend the workshop to provide another view of proceedings. The Secretariat has also looked to other areas of the NEA to provide insight into current practice in related areas on Radioactive Waste Management.

Consultants and NEA specialists

- Marcos Buser
- Richard Ferch
- Meritxell Martell
- Cécile Massart
- Lumir Nachmilner
- Mikael Jensen
- Ian Hill – NEA Databank
- Gloria Kwong – NEA IGSC
- Ivan Rehak – NEA WPDD

The project would furthermore like to thank the following guests for their participation in the workshop:

- Anastasia Iline, Service interministériel des archives, France
- Hugo Ceulemans, MONA, Belgium
- Mareike Rüffer, The Federal Office for Radiation Protection
- Vio Szabo, Municipality of Östhammar, Sweden
- Johanna Yngve Törnqvist, Municipality of Östhammar, Sweden
- Candida Lean, Environment Agency, UK

- Maria Liouliou, UNESCO
- Anders Högberg, Linnaeus University

Overall

The project is accumulating information and data through an increasing number of focused initiatives. These initiatives are featured throughout the workshop – please see items 2, 6, 7, 12, 23, 31, 37, and 40. These initiatives should help make progress towards developing the final deliverable of the project, a 'Menu-driven document' which will be published in 2014.

The project has support from project members. It is reaching out to more audiences, receiving their input, and establishing international visibility.

The Secretariat would like to thank all project members and guests for their participation in the workshop, particularly the moderators and presenters for their valuable contributions to the project.

Organisation of the Proceedings

Please note that the numbering of the presentations is consistent with the numbering in the agenda.

These proceedings present the abstracts as they were kindly provided by the presenters. These abstracts are followed by any immediate discussion notes, although most discussion is documented in the 'Plenary Discussions' at the end of the sessions.

Summary of the Workshop

Key observations and messages for the programme of work of the RK&M project

Regulation

1. RK&M is not a regulatory requirement for long-term safety. The Safety Case, however, typically has the implicit assumption that RK&M will be preserved for some centuries - for example, in order to protect the repository from human action. The RK&M project is substantiating how this preservation of RK&M can be accomplished – for example, through the identification of the multiple national and supranational mechanisms that already exist. *C.f. 2, 3, 4.*

2. The Regulatory Catalogue is a good addition to the RK&M project materials. However, regulation cannot be seen as the only solution to the problem – especially if regulation stops at the simple requirement to 'keep any relevant records'. *C.f. 2, 4, 31.*

3. The preliminary analysis of the Regulatory Catalogue shows that there is currently no emerging trend to be seen in how to regulate the preservation of records, knowledge and memory for the final disposal of radioactive waste. *C.f. 2.*

4. From a regulatory point of view, there are requests from the EC to detail post-closure memory preservation plans. The upcoming guidance by the ICRP (document ICP-122) is based on the concept of oversight, which relies on RK&M preservation *C.f. 3, 6,7.*

Bibliography

5. Within the project, the analysis of the RK&M bibliography is progressing. The early indication is that a number of areas have received relatively less attention. Namely, the question of establishing costs and funding for activities that may be required for ongoing preservation of RK&M; the role of NGOs in RK&M; the role of monitoring in both creation and preservation of RK&M; security and safeguards as motivations for preserving RK&M; questions about actions that might be taken in the long term to preserve RK&M and/or to mitigate loss of RK&M; and the role RK&M preservation might play in ensuring the existence of future expert knowledge needed to help preserve and interpret factual data and metadata in the longer term. *C.f. 16.*

Records and Archives

6. Current archiving requirements are very general – asking, for instance, for 'all relevant information'. Also, there is a prevailing preference for analogue material. The necessity to keep archives in more than one location is mentioned in legislation, but rarely put into practice as of yet. It was questioned whether National Archives are the best place to preserve nuclear records. There may be benefits in having a specialised National Nuclear Achieve, as being developed in the UK. *C.f. 31, 35, 36.*
7. Technical developments in this area – such as the 'Sapphire Disks' – should be noted. *C.f. 29.*
8. The principles of durability, readability and retrievability were identified in the CEA presentation as good practice for record keeping in decommissioning. *C.f. 41.*
9. The principles of durability, readability and retrievability will be important to the development of the Minimal Set of Records. This work area has identified that a Minimal Set

of Records would be a useful tool in the medium term and long term, and that there needs to be a prioritisation and justification of key records. *C.f.37*.

10. The survey and analysis of examples of the loss of records in the case of hazardous waste facilities indicates that (lack of) human action is the most important factor – principally in terms of regulatory enforcement, followed by economic factors (lack of funds). Technological failure plays a third role according to the study presented. *C.f. 12*.

Oversight and Monitoring

11. Oversight is a fundamental concept in the upcoming ICRP guidance on geological disposal. The concept was introduced initially by the R&R project.[1] Oversight requires the presence of man and covers activities such as regulatory supervision, societal involvement in the project, preservation of RK&M, and the verification of land use restrictions. *C.f. 6, 7*.

12. According to ICRP there must be willingness to continue Oversight activities of the repository beyond closure. However, there is concern that these activities will be seen as compensation for lack of intrinsic safety, or even that some forms of monitoring could interfere with the technical safety of the repository. *C.f. 6, 7*.

13. An initial survey on behalf of the RK&M project observes that more than half of the respondents indicate that there is an interest in local communities on the issue of preserving RK&M of the radioactive waste management facility for time periods beyond closure. When asked whether any actors in the national context acknowledge that local communities could play a role in monitoring and RK&M preservation, the responses are positive in almost two thirds of the cases. *C.f. 7*.

14. There are three main drivers for post-closure monitoring of geological disposal facilities: technical, societal and safeguards. All of these will contribute to oversight and therefore to RK&M. More specifically, the following reasons have been given for post-operational monitoring: safeguards ; understanding the evolution of the near-field; determining the post-closure evolution of the geosphere; evaluating the impacts of the repository on the surface; confirmation of performance assessment assumptions; aid to decision-making, e.g. for retrieving the waste or ending the institutional control phase; public acceptability and confidence; and legal requirements. *C.f. 6*.

15. The DOE Office of Legacy Management has 'Oversight' experience that will be valuable for our NEA project. Initial lessons are:

    a. The conditional re-use of sites enhances the concept that the site is sufficiently safe; it's a way to create memory and a sense of ownership in the community.

    b. Oversight may be carried out by others than the original regulator (of transfer of responsibilities from actual licensing body to a new oversight body). The new oversight body will be happy to have reasonably complete records; it should be remembered that what is considered complete may change – for example, if regulatory requirements change.

    c. The regulatory concept of Risk-based Closure does not close debates about risk in the rest of society and it is a deterrent to transferring site responsibilities. *C.f. 21*.

Knowledge and Knowledge Management

16. Knowledge can evolve from having been broadly spread to be carried by only a few hands and can also jump between different social and cultural categories. In Sweden, for instance, the most prominent carriers of the knowledge of how to manage and ride horses are no longer either land-owning farmers, or nobility, but schoolgirls and their instructors. Also, knowledge can slowly transform so that original practitioners may not be able to recognize the current practices or their followers of today. *C.f. 11*.

[1] The OECD NEA Reversibility and Retrievability Project - http://www.oecd-nea.org/rwm/rr/.

17. In order to allow future generations to make sense of the repository, there is a tension between the desire to provide a 'full context' and the need to 'cull' information, so that only the essential is retained and is accessible and understandable. This tension could be resolved through innovative knowledge management. The knowledge we need to preserve may be defined and retained through a management strategy. *C.f.*

18. Sellafield, UK, is currently using a knowledge retention strategy to conceptualise the preservation or discard of records and knowledge over a hundred year period by mapping knowledge and defines when it will be needed and how it should be managed – that is, if it should be 'consolidated', 'forgotten', 'mothballed', and so on. The reliability of these methods over longer timescales needs to be researched. *C.f. 12,14,15.*

19. ONDRAF/NIRAS uses safety and feasibility statements, as a structuring tool for the safety case. These act as a consistency check between system requirements and components, serve as guiding tool for the requirements of technical specifications for construction of the repository and its components. This increases the consistency between the safety and feasibility cases, helps to prioritise research and constitutes and basis for dialogue with stakeholders on safety aspects and design. They may be used for identifying RK&M needs, at least at technical level and through full licensing of the facility. *C.f. 19.*

Engagement

20. It is not just institutions that can change over the timescales under discussion. Concepts such as monitoring and archives are societally determined, and may therefore evolve and be superseded. The regeneration of artistic elements on the site could provide a mechanism for continuous oversight. Another related approach is the ANDRA investigation into the use of rituals to foster memory in the medium term. *C.f. 8, 10, 24.*

21. Concepts such as the 'sacrificial layer' and "regeneration" are useful in understanding how people develop and change their heritage. A 'sacrificial layer', as identified by the Long Now Foundation, is an apparently valuable element of a monument or artefact which can be lost without losing the monument itself. For example, the pyramids were originally plastered; this has been lost, but the pyramids remain. These concepts can help us understand how the creation of a point of engagement – such as a monument or a ritual – need not be created to withstand a changing environment but should be expected and designed to engage with the generations as its means of survival. The project can investigate these ideas further, e.g., through collaboration with organizations such as the DoE's Office of Legacy Management. *C.f. 5, 24, 27, 28.*

22. In considering the transmission of the messages that programmes want to preserve, we should create 'Sense Making' strategies – that is, strategies which allow future generations to make sense of the cultural and symbolic messages that we leave (through written records, artefacts, ect.). We can aid future generations in better making sense of the past through providing a rich context of sources that cross-reference one another. *C.f. 14.*

23. "Sense making" is limited to time scales of a few thousands of years. For the longer term, strategies for information transfer should eliminate the idea of using cultural and symbolic messages. If we take the idea of 'talking to extraterrestrials' to model these ideas, we see that we are considering communication that cannot assume any common understanding of cultural symbols. One answer to this challenge is perhaps to use the physical existence of the waste (rather than its records or the symbolic meaning of it). Could the waste be a means of transmitting cultureless signals, such as mathematical code, which bypasses the need for cultural interpretation? *C.f. 13.*

24. The success of RK&M preservation cannot be judged only by whether they last for one thousand or ten thousand years – the success is in whether the attempt establishes the need and responsibility in the minds of regulators, operators, stakeholders and the general public, and [2]whether that need and responsibility is understood and passed on to the next generation. *C.f. 27.*

25. Access to information about a place or object increases the value in which it is held. Existing mechanisms for memory preservation such as the UNESCO World Heritage Register show that official recognition of the societal value of a place or object is a powerful way to create a wider and more enduring respect and interest in that place or object. This access to information must be proactively created. *C.f. 23, 32.*

Costs

26. The PIC programme of WIPP and the decommissioning experience provide useful models to begin thinking about how to identify the issues of costs and pragmatic organization of RK&M preservation. Ultimately, the concept should be "practicable".

27. The WPDD survey and the CEA presentation identified that a key point for RK&M loss was at the transfer from operation to decommissioning, because operational data was collected without thought to how the data needs would be different for a site undergoing decommissioning. *'There will be significant financial consequences if there is inadequate documentation to support decommissioning'. C.f. 27, 42.*

28. The ANDRA Memory Programme bases the assessment of costs with the *date* and *nature* of the cost. There could also be created sources of revenue, such as museum visits or scientific research. It may be necessary to develop a dedicated fund for RK&M, e.g., building on lessons learnt from the Nobel Foundation. *C.f. 43.*

Mechanisms

29. A number of supranational mechanisms are being analysed with a view to understand their viability over the medium term. *C.f. 18.*

30. There exist many independent mechanisms and requirements for environmental monitoring, memory preservation, of which nuclear RK&M programmes should be aware and take advantage of. *C.f. 8, 18, 23, 32, 33, 34.*

DAY 1

SESSION 1 - INTRODUCTION AND UPDATES

1. Introduction to the Workshop

Claudio Pescatore welcomed the delegates, guests and presenters to the Workshop. The Agenda was reviewed, and the thematic organisation of the Workshop was introduced. Please see the introduction to this document.

WHY PRESERVE RK&M

SESSION 2 - THE SAFETY STORY

2. Catalogue of Legislation, Regulation and Guidance Governing the Preservation of RK&M for the Final Disposal of Radioactive Waste

Helen Gordon-Smith, NEA

This presentation is an analysis of the information gathered through the Catalogue project, which was introduced to the group at the April 2012 Project Meeting. The aim of the Catalogue is to collate all of the existing legislation, regulation and guidance (hereafter referred to as 'regulation') in member countries, the IAEA and the EU, which currently govern the preservation of RK&M for the final disposal of radioactive waste.

Overview

There is a wide variety of regulatory approaches shown in the Catalogue. Requirements, where they exist, legislate civil nuclear activity as a whole, facilities generally or specific facilities, radioactive waste disposal, or radioactive substances. There is, in brief, a broad range of types of regulation, as well as differences in binding nature, focus and scope, including regulations, decrees, environmental permits, EU Directives, and guidance to the regulations.

Analysis

In order to provide an analysis, I have applied a set of criteria to show where different regulations dealt with similar topics. These criteria are based on the questions asked in the 2010 Survey of Needs, which preceded the project, and the 2012 survey of the Regulator's Forum, as both of these surveys specifically looked at what was currently being regulated.

Applying these criteria necessarily involved some interpretation, and members are asked to review their profiles – any comments would be gratefully received.

1. Time Scales

a. Very Short Term
Canada, The Czech Republic, Switzerland and the UK cover this, largely in terms of the immediate responsibilities of the operator in compiling records.

b. Short Term
Canada, Hungary, Sweden, Switzerland and the UK cover this, again largely in terms of the responsibilities of the operator before closure to maintain records.

c. Medium Term
There were several requirements which could be interpreted as lying within the project's definition of the medium term. Requirements which encompassed both the medium and long term were categorised as 'long term'.

Canada requires records to be kept while the facility is under regulatory control, and Switzerland requires the license holder to maintain records until the end of the monitoring period. The UK states that the required records should be maintained until the license holder is notified by the regulator. Germany states that records are to be kept for 'a period after the final sealing of the repository.'

The EU requires all national programmes to include concepts for RK&M preservation 'for the post-closure period of a facility's lifetime, including the period during which appropriate controls are retained'.

The IAEA, on the other hand, recommends that post closure 'controls' – which are taken here to include RK&M preservation – be developed as the facility approaches closure.

d. Long Term
The EU stipulates that plans for post-closure must include the means to preserve knowledge about the facility 'for the longer term'. The IAEA states that 'long term safety' cannot rely on active institutional control, but passive controls could reduce the risk of intrusion over a 'longer timescale' than the one envisaged for active controls. Clarification is needed as to whether the meaning of these terms is consistent with the project definition, being the time with no repository oversight.

In the Czech Republic, records on geological activities must be passed to the Czech Geological Service for 'permanent' storage. In Finland, STUK are required to arrange the 'permanent recording of information concerning the disposal facility and disposed waste.' In Swiss Nuclear Energy Ordinance, markers must be 'permanent'. The USA regulations clarify that markers cannot be relied on to provide safety, but nonetheless all facilities will be required to establish appropriate markers and records.

2. What Should be Preserved

Records

All of the countries with relevant regulations had information on what records should be preserved. The EU and the IAEA did not make any specifications regarding which records to preserve.

Knowledge

The EU, Switzerland, the UK and the USA all mention the preservation of knowledge. The EU demands that the required concepts or plans for post-closure should include 'the means to be employed to preserve knowledge of that facility in the longer term'. The guidance in Switzerland specifies that 'documentation has to be prepared on long-term securing of knowledge of the geological repository', and the UK guidance consistently refers to the preservation of 'knowledge and adequate records'. The UK guidance also provides information on what meta data to preserve. In the USA, the EPA regulations for WIPP require measures that will be used to 'preserve knowledge' about the repository.

Memory
No regulations mention the preservation of memory.

3. Why Preserve RK&M

a. Safety Requirement
b. Licensing Requirement

Germany and the EU give only safety, or future safety assessments, as the reason for RK&M preservation.
In Canada and the UK, keeping records is part of the operating license. In the USA, the submission of records is part of the license for the closure of the facilities at Yucca Mountain and WIPP.

It is stated in the US and the IAEA regulations that the safety of the facility cannot rely on RK&M preservation, but where the reason for preserving RK&M is elaborated – that is, in the UK guidelines and the US WIPP regulations - the reason given is to increase the safety of the facility, usually in order to prevent intrusion.

4. Where RK&M Should be Preserved

In Switzerland and the USA, the use of markers implies that the site of the repository will be, at least in part, where RK&M will be preserved. The UK guidance has a section on the National Nuclear Archive. The Swiss guidance specifies that records will be kept in 'three separate locations', and in Germany and the Czech Republic, it is specified that records will be stored in 'two different locations'.

5. How RK&M Should be Preserved

a. Protection Zone
Three countries stipulate that there will be a protection zone. Finland simply states that one shall be created, where Switzerland and the USA go into further specifics. Interestingly, Switzerland sets out a licensing system whereby the land in the protection zone may be available to commercial interests, whereas in the US regulation the land is completely withdrawn from public use.

b. Markers
Only Switzerland and the USA stipulate that the repository will be marked.

c. Archives
According to the Czech Republic archiving Law, RAWRA cannot discard any official document without the permission of the National Archive, and the documents shall be transferred to the National Archive periodically according the "discarding plan". Switzerland stipulates that the licensee should keep all construction and operating records until the end of the monitoring period. The USA regulations require that records be submitted to local, State and Federal archives before closure. The UK guidance states that the records which accompany waste will eventually be transferred to an archive facility, and gives an overview of the planned National Nuclear Archive. Sweden has 'Regulations concerning archiving at nuclear facilities', but unfortunately I could not include it in this paper as it is only available in Swedish.

d. Records management
I interpreted requirements on how to organise, update and transfer records and 'records management'. The Czech Republic, Germany, Switzerland and the United Kingdom have requirements which fall into this subcategory. These were either very short-term or short-term requirements which laid out the responsibilities of operators to compile and maintain adequate documentation.

6. For whom Should RK&M be Preserved? Accessibility Requirements

a. public/ general access
The EU sets out requirements for transparency and access, stipulating that 'Member states shall ensure that all necessary information on radioactive waste be made available to workers and the

general public…' Sweden's requirement is not for transparency, but that 'any measure to facilitate access or make intrusion more difficult' will be assessed against any effect on the protective capability of the repository.

b. commercial interests
In the US regulations, it is specified that records need to be placed in archives that 'would likely be consulted by individuals in search of unexploited resources'. Commercial interests are considered in Switzerland's regulation on the protection zone, which set out a licensing system for use of the land.

c. government – right of access to RK&M
Germany, Switzerland, the UK and the USA stipulate the government's right of access to operator records.

d. control of access to RK&M
In the Swiss Nuclear Energy Ordinance, the supplier of the records and the Swiss Federal Geological Information Centre are contractually required to regulate the conditions of access to and use of the data. The UK guidance has provisions to control access to the records in order to protect national security.

7. Organisational Responsibility for RK&M Preservation

In the Czech Republic, post-closure responsibility for preserving RK&M for geological activities lies with the Czech Geological Service, who must keep the records 'forever'. Under the archiving Law, RAWRA must transfer all selected records to the National Archive for a permanent storage. The IAEA assumes that responsibility will revert to government 'at some level'. The German regulations require records to be held by the Federal Government after the sealing of the final repository. The UK guidance gives an overview of the planned National Nuclear Archive. Canada and Switzerland stipulate that licensees are to keep records 'whilst the facility is under regulatory control', and 'until the end of the monitoring period' respectively. In Switzerland the responsibility of the Federal Council to preserve RK&M is implied by the protection zone licensing system. The Swiss regulations also say that after the monitoring period, documentation should be handed over to a government agency.

Conclusions

While the aim of this paper is a thematic analysis of the regulation, this has revealed the differences between national approaches more than it has drawn out the similarities. For example, while it is true to say that five countries have requirements concerning archives, there is a wide range of time scales (from five years to forever) and levels of specificity about the location and the records to be included. Similarly, the diffusion of information about, for example, licensing requirements, means that it is difficult to say with precision which country has what regulation for RK&M preservation. There is also the problem with comparing very different types of documents.

This paper is therefore limited in its ability to analyse the current nature of regulations governing RK&M preservation for the final disposal of radioactive waste. I anticipate that the Catalogue will become smaller as it is narrowed down to those articles which can be described precisely as governing the preservation of RK&M for the final disposal of radioactive waste. This would cut out, for example, a lot of the information on 'what' is to be preserved, as this largely comes from very short term operating requirements.

In conclusion, the variety of approaches and topics covered in these regulations shows that there is currently no emerging trend to be seen in how to regulate the preservation of records, knowledge and memory for the final disposal of radioactive waste.

3. The Implementation of the European "Waste Directive": Aspects Relevant to RK&M

Claire Mays, Claudio Pescatore, Helen Gordon-Smith, NEA

Context

The *Council Directive 2011/70/Euratom of 19 July 2011 establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste*[2] is to be transposed into national law of European Member States by 23 August 2013. One article of this "Waste Directive" has direct relevance to the preservation of records, knowledge and memory (RK&M).

In the context of the NEA project on RK&M, a survey was made in Summer 2012 of how the relevant article may be taken up in the national policy, plan or programme of European countries represented in the NEA project. Responses to the questionnaire, presented below, are not to be construed as official national positions. Instead these are observations provided by project members to stimulate discussion at the 2nd RK&M workshop held in September 2012.

Relevant excerpt from the "Waste Directive":

Article 12(e): *[National programmes should include…] concepts or plans for the post closure period of a disposal facility's lifetime, including…the means to be employed to preserve knowledge*[3] *of that facility in the longer term.*

Respondents to the RK&M Questionnaire

Nine replies were obtained, from project member organisations in Belgium, Czech Republic, Finland, Germany, Hungary, Sweden, Switzerland and the United Kingdom. These organisations included three safety authorities, an R&D institute, and five implementers.

I would start (not end) with the questionnaire

Summary of replies to the RK&M Questionnaire

The actual questions have been grouped and/or rephrased for convenience of presentation in this summary.

A. Is post-closure 'knowledge' already part of your National Waste Management Plan, if one exists?[4] If so, what does the plan say about the means to be employed to preserve this memory?

The UK reply notes only that a plan does not yet exist.
Other country replies considered existing legislation, regulations, or submitted documents that have aspects of a "national plan". All replies indicate that memory issues have been identified as needing to be part of a (present or future) plan.

Replies focusing on existing regulation (ordered by country):

- In Finland, knowledge is recognized in legislative documents which require implementers to maintain records of disposed nuclear waste packages, and deliver summary records to the Radiation and Nuclear Safety Authority (STUK) yearly. STUK transfers information to be entered in the real estate register, land register or list of titles. Legislation also requires that STUK shall arrange the permanent recording of information concerning the disposal facility and disposed waste. Preservation of records is not described in nuclear energy legislation. Archiving legislation directs the National Archives of Finland to execute the permanent preservation of records.
- The German reply identified existing safety requirements (2010) which could be considered a plan, and in which post-closure "knowledge of the facility" is an issue. These state that -

[2] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:199:0048:0056:EN:PDF.
[3] The term "knowledge" employed in the Directive appears to correspond to the term "memory" as defined in the RK&M Glossary (q.v.). "Longer term", in the same sentence, appears to correspond to "medium term" as defined in the RK&M Glossary. www.oecd-nea.org/rwm/rkm.
[4] Replies first had to interpret whether existing national legislation could be construed as a "plan". The German reply noted that Article 14 cites "programme" in the sense of the Directive Article 11.

"complete sets of documents must be stored in at least two different suitable locations" - "prior to decommissioning, regulations shall be adopted concerning the scope, preservation and accessibility of the documentation" and - "this [documentation] should include information regarding the area surrounding the repository mine that must be protected from human intervention in the deep subsoil".

- In Hungary, the present decree on requirements for siting and planning of disposal facilities contains a laconic statement on RK&M: *"measurements and data gathered during research shall be stored until decommissioning or closure of the facility or conclusion of the institutional control."*
- In Sweden, enactments of safety regulations concern archiving at nuclear facilities and the National Archive. The archive shall be handled in a way that makes it possible to read all information and if necessary transfer to other data carrier. The property of nuclear waste, treatment and final disposal should be documented and be kept for long-term storage, which means a time period of more than a hundred years. (One interpretation says that the memory topic is only mentioned as a future need in brief and general terms.)
- In Switzerland, documentation and archiving are issues found in the current nuclear energy legislation. Details were provided in this response as to objectives of memory, type of record, contents, institution(s) responsible, conditions of preservation, and periods. Notably, "*the owner must hand over all documentation to the [supervisory] Department after closure or on expiry of an additional monitoring period*".

Replies focusing on future regulation:

- In Belgium, memory keeping was an important issue in the legally foreseen public consultation of the SEA procedure. Therefore ONDRAF/NIRAS has included transfer of knowledge to future generations as a condition for the further development of geological disposal in the final version of its Waste Plan as submitted to the government in 2011. This states: "*The transfer of knowledge to future generations can be organised at both national and international level, in particular by means of the reports to be provided under international obligations. However, it will be up to each generation to determine what knowledge and resources it wants to transfer to the next generation.*"
- In the Czech Republic, post closure knowledge is not included in the existing National waste management plan (2005). But the new plan is in preparation that should comply with the EU directive.
- RK&M related issues will be a part of the future Hungarian National Waste Management Plan now under discussion.

B. Which organizations or actors in your country will be involved in preparing the transposition of Article 14 of the Waste Directive?

Most replies indicate that the transposition will involve consultation and/or shared responsibility among actors.

In two countries the transposition actors are not yet set:

- The Waste Plan proposed by the Belgian implementer states: "The scope of this transfer will have to be further specified in dialogue with all stakeholders taking into account the need to meet the requirements regarding safety and technical and financial feasibility."
- In Hungary the designation of actors remains under discussion.

The reply obtained from Finland suggests that the transposition will be a matter of continuity with existing provisions:

- Implementers of waste disposal have to maintain records of the disposal operations and report summary yearly to STUK (regulator). In the future National Archives will also participate in preservation of relevant information.

In other countries, most replies mention safety authorities including government departments, with planned or possible collaboration with other actors:

- In Germany: Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). It is at the discretion of BMU to involve other organizations or actors.
- In Sweden: regulator SSM will prepare a proposal on how to implement the Waste Directive including this topic after listening to stakeholders including implementer SKB.
- In Switzerland: Implementer (Nagra), regulator (ENSI) and the Swiss Federal Archives (BAR)
- In the UK: DECC, assisted by RWMD (NDA) *(abbreviations in between brackets following description as with other bullets above)*

In the Czech Republic, only the implementer, RAWRA, is mentioned as being responsible for the draft of a new National waste management plan.

C. Which steps may be taken in your country to prepare the transposition?

The UK reply suggests that ENEF guidelines will be followed.

The German respondent is not aware of any official statement of BMU regarding the steps to be taken to prepare the national programme.

Three countries require a prior decision milestone, or other legal preparation:

- In Belgium the implementer assumes transposition of the public 'transfer of knowledge' requirement (and not transposition of EC directive). In that case, further steps can only be prepared after a Decision in Principle is taken by the government.
- Czech Republic: Approval of a new State energy policy is a precondition of a new waste management policy plan - approval is expected in this year.
- Hungary's next step is to build up the necessary legal background *??*.

In three countries the transposition process appears to be integrated into a process already underway:

- Finland: Effects of the directive as a whole on Finnish legislation will be analyzed during autumn 2012. Discussions between STUK and National Archives of Finland shall be started in order to clarify responsibilities in preservation of records, knowledge and memory.
- Sweden: Essential requirements are given in the enactments. It is probable that the authority will impose additional requirements if a license is granted. A final solution is not yet completed. The enactment is being reviewed and will be revised shortly. Among other things the archive kept for any nuclear activity shall be submitted to the Swedish Radiation Safety Authority if the activity ceases.
- In Switzerland, the regulator controls knowledge transfer within the organisation of the implementer. Paths of documentation are established.

D. What is the calendar for preparing the transposition?

In Belgium, Hungary, and the UK, the calendar is not yet set.
Other countries have some defined dates:

- In the Czech Republic, the first draft of the national radioactive waste management plan should be sent for comments in second half of 2013, and we expect that it will be approved by the government in 2014
- In Finland, the clarification of responsibilities between STUK and National Archives of Finland will be done during 2012.
- Germany will rapidly transpose the Directive into national law and present a national programme within the timeframe specified by the Directive by 2015.

- In Sweden, a proposal prepared by the regulator (SSM) is now under review by stakeholders. The Government expects comments not later than 19 October 2012.

In Switzerland, the safety authority replies that final documentation after closure will probably be in 100 years from now (due to an observation phase required after emplacement). Thus, no detailed planning is currently needed.

E. Is your organization considering the post-closure 'knowledge' requirement also within the more general requirement on Transparency (Article 10 of the Waste Directive[5])? Is explicit reference being made to Article 10 when considering RK&M provisions?

In Belgium, Germany, Hungary, and the UK, terms will be clarified when the transposition or corresponding process is underway.

Remaining country replies indicate that transparency certainly does frame RK&M requirements:

- In the Czech Republic "transparency" is included in the Atomic act and it is not limited to any period of the repository lifetime - so the information should also be available in the post closure period.
- Finland cites the Act on the Openness of Government Activities (621/1999).
- Switzerland's current ongoing site selection process (sectoral plan) is designed to be as transparent as possible.
- In Sweden, the implementer replies "yes, we make no difference. The topic of post closure knowledge needs to be discussed openly." The safety authority notes that in compliance with the principle of public access everything registered at the authority is open and available to the public.

No reply mentions explicit reference to Article 10, because existing legislation predates the Directive, or because the transposition process is not yet at such a stage.

Questionnaire to the European Members of The Preservation of Records, Knowledge and Memory across Generations (RK&M) project.

The Council Directive 2011/70/Euratom of 19 July 2011 establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste is to be **transposed into national law by 23 August 2013.**

This questionnaire asks how a Directive article with direct relevance for RK&M is to be taken up in your national policy, plan or programme. Results of the survey will be presented and discussed at the September RK&M workshop.

Excerpt from the "Waste Directive":

Article 12(e)

[National programmes should include…] concepts or plans for the post closure period of a disposal facility's lifetime, including…the means to be employed to preserve **knowledge*** of that facility in the longer term. *{**Memory* in the terms of the RK&M glossary}*

Question 1

Is post-closure 'knowledge' already part of your National Waste Management Plan, if one exists?

Question 1a What does the plan say about the means to be employed to preserve this memory?

[5] **Article 10:** *Member States shall ensure that necessary information on the management of spent fuel and radioactive waste be made available to workers and the general public. This obligation includes ensuring that the competent regulatory authority inform the public in the fields of its competence…*

Question 2

Otherwise, which organizations or actors in your country will be involved in preparing the transposition of this requirement?

Question 2a Which steps may be taken in your country to prepare the transposition?

Question 2b What is the calendar for preparing the transposition?

Question 3

Are you considering the post-closure 'knowledge' requirement within the more general requirement on Transparency? ("Article 10: Member States shall ensure that necessary information on the management of spent fuel and radioactive waste be made available to workers and the general public. This obligation includes ensuring that the competent regulatory authority inform the public in the fields of its competence…")

Discussion Notes

It was asked if more detail could be given on who had given which answers to the survey.

It was agreed that this information could be posted on the project website, but emphasized that the purpose of the questionnaire was to create an informed impression of the status of country plans with regards to the Waste Directive, rather than establishing the official positions of the member states.

4. RK&M preservation and the Safety Case: Results of the Integration Group for the Safety Case (IGSC) questionnaire

Gloria Kwong, NEA

In 2012, to gain further insight on links between the preservation of Records, Knowledge and Memory (RK&M) and the safety case during the post closure period, a short questionnaire consisting of 4 questions was distributed to the IGSC members to seek a base level of information (i.e. no extensive details). The questions are:

1. *Does the post-closure safety case for a geological repository as currently developed in your context mention intentional RK&M measures to enhance confidence in safety? Alternatively, does your post-closure safety case simply make assumptions with respect to knowledge preservation?*

2. *In the post-closure safety case for a geological repository as currently developed in your context, which elements will imply gathering and maintaining records post-closure?*

3. *In the post-closure safety case for a geological repository as it is currently developed in your context, which elements will imply fostering societal memory of the repository and/or RWM?*

4. *In your post-closure context, has a societal request (as distinct from regulatory demand) for preservation of RK&M been heard, which impacts the development of the Safety Case for a geological repository? If so, please describe.*

Ten (10) organisations from 9 countries (Belgium, Canada, France, Germany, Netherlands, Sweden, Switzerland, UK, and the USA) sent their replies. For the most part these replies did not answer the questionnaire directly, which indicates that many programmes are in an early stage of addressing RK&M issues in their safety case. In the replies, many programmes assumed RK&M would be preserved for a few hundred years, during which human intrusion would not occur. Some programmes did mention record keeping and site marking measures. However, it is unclear whether these measures are to be implemented within the framework of the safety case, i.e. so as to enhance safety. Nevertheless, human intrusion remains a concern to almost all programmes, particularly in the post-closure phase, and is often considered as a key driver for records preservation.

The replies also showed that most safety cases, at the present stage, do not have specific measures to foster societal memory even though some programmes expressed their recognition of the

importance of societal memory. While formal societal request from local publics to address RK&M preservation has not been received, many programmes indicated that informal discussions with communities to discuss their expectations had taken place. It was observed that RK&M requests from local publics do not specifically address post-closure issues and do not require specific actions impacting the safety case. Finally, the survey noted that many programmes recognize that long-term safety of a repository cannot rely upon the preservation of RK&M or active human control. These programmes may use RK&M preservation measures to improve their 'safety story' by fostering confidence in protection of people and the environment, but these measures are not described or used in the safety case and safety assessment to demonstrate long-term safety.

5. Exhibition Introduction: "How Do We Communicate Something That Is Beyond Our Control And Yet Is Dependent On Our Choices?"

Cécile Massart, Artist

This presentation introduced an exhibition of Cécile Massart's work, which was held in the meeting room for the duration of the workshop. To see Mme Massart's portfolio, and for more information on her work, please visit http://cecile-massart-lisibilite-dechets-radioactifs.com/en/.

I have been involved in successive projects, exhibitions, reports, publications and meetings, dealing with, among others:

- An archived site for alpha, beta, gamma
- Archives of the future
- Cover
- Awareness of the landscape

I have spent 10 years to travel and consider the identification of waste and the various media for archiving, writing, engraving, photographing.

That's 10 years to try and find an answer to today's key question:

"How do we communicate something that is beyond our control and yet is dependent on our choices?"

In the future, how can we read these archaeological layers of the 20th and 21st centuries on the surface?

From now on, we must find a "framework" for cultural and societal references.

Through my work I am striving to create a "framework" for these archives, one that is legible by man.

I was working on a photographic report about the El Cabril site in 1998, when I first realised that we had to act to combat the idea of camouflaging sites and that this needed to be discussed urgently.

Through exhibitions, I discovered that the general public were unaware of the existence of the sites and that information was extremely confused and sensational.

So I propose working on the surface of sites, within the countryside, because we are the prehistory of this communication.

In the future, technology will pass on our work.

Aware of the current political, ethical, and economic landscape and knowing that man will continue to be responsible for this communication for a few generations, handing down the memory, these places can become testing grounds for art in general, including other disciplines.

I call this vocabulary to be read in the landscape "markers or archisculptures", not shows (as in the traditional exhibitions by an artist) but a work of continuous creation, respectful of local societies and regional and international economic issues.

Creating interesting places to visit, shaped for perpetual communication, and thus establishing a sustainable communication:

Art-technology-earth-energy-human generations all communicating as one.

A divided memory, recorded on different media and in different places.

So, I am not in favour of maintaining the "markers" but instead, regeneration in a similar way to the modern lifestyle in times to come. This leads to the idea of continuous monitoring of the site.

In doing so, the "markers" become a part of the emergence of a new type of "work" created with employees, scientists and engineers, supported by partners, dedicated to an unsentimental modification, regeneration or destruction.

Time, population movements, future sociotypes, the view of this type of waste and the economy play a significant role.

To achieve this, local society, an artistic institution and a project's owners in synergy with the agency will make the decision about the types of works covered by this laboratory.

This creates a certain dynamic and makes the sites iconic.

This specific, innovative and remembered environment is likely to boost the local economy.

It opens up a new, multidisciplinary, multicultural and multifunctional field.

Originality will be "studied simplicity".

There is no question of a sophisticated and costly operation, but instead one that reveals the natural elements of this place.

This project enables a community to create a unique project.

It breaks with the image of the past and opens a research laboratory from a memorial perspective.

It is also a platform which could give our history the foundation for a revival of the role of the future artist, remaining in the background to work in the face of emergencies.

It provides the warning signals of a nuclear aesthetic in the active and positive sharing of this memory.

6. Monitoring following repository closure

Motto: Confirming or questioning safety ? (A. Bergmans)

Lumir Nachmilner, Consultant

There is clear consensus in the disposal community that once a geological disposal facility is closed (including the access tunnels and shafts), it attains the status of passive safety and, as a consequence, its safety is no longer dependent on monitoring. In spite of this, post-closure monitoring is envisaged in most disposal programmes.

The geological disposal system will be required to provide for the determined safety levels for a period of at least tens of thousands years: the containment of radionuclides within the engineered disposal system is typically designed for a number of millennia. Therefore, the monitoring of nuclear parameters in the time frame of a number of decades or centuries seems to be of little use. Rather, the long-term safe performance of geological repositories will be guaranteed by the attainment of ‘passive safety’ status which does not rely on human intervention. However, providing a practical demonstration of having achieved such status is far from easy: the lack of representative criteria and

suitable measuring techniques requires the involvement of indirect proof developed at research and test facilities.

The technical drivers for post-closure monitoring may include willingness to keep reviewing selected baseline data, improving the understanding of the repository system evolution both for performance confirmation and as an aid to decision-making (for example, on whether and when to, end monitoring, or to retrieve the waste). Other objectives may include monitoring supporting facility oversight period, keeping the memory of the facility during this period and preserving knowledge of that facility in the longer term. Several approaches have been considered by different disposal programmes, however – accepting that this issue will mostly become topical after a period of many decades – no clear output has been defined.

Society may demand the on-going monitoring of certain parameters, typically those which provide for the assessment of environmental impacts following final repository closure and sealing.

Consequently, the selection of parameters might well be driven by socio-political rather than technical considerations. The extent of societally induced post-closure monitoring programme will essentially be determined by decisions made at the time of closure; it would seem appropriate that such decisions be taken by the generation responsible for final disposal.

A specific post-closure monitoring task will deal with the ensuring safeguard obligations. The various principles and techniques have been determined, the only question that remains open is exactly when such a project should be terminated.

To summarise, there are three main drivers for post-closure monitoring of geological disposal facilities: technical, societal and safeguards. Once a post closure monitoring option is to be introduced, the following questions should clearly be answered: why, how long and how to monitor.
Countries that are planning to implement comprehensive post-closure monitoring consider the following reasons for developing a post-closure monitoring programme:

- Safeguards (Belgium, Canada, Germany, Netherlands, Spain, Sweden, Switzerland).
- To understand the evolution of the near-field (Netherlands, Sweden).
- To determine the post-closure evolution of the geosphere (WIPP, Belgium, Canada, Netherlands, Russia).
- To evaluate the impacts of the repository on the surface (Canada, Netherlands).
- Confirmation of performance assessment assumptions (WIPP, Yucca Mountain, Canada, Finland, Spain).
- As an aid to decision-making, for example to retrieve the waste or to end the institutional control phase (Belgium, France, Japan, Netherlands).
- Public acceptability and public confidence (Belgium, Canada, Germany, Japan, Sweden, Switzerland).
- Legal requirement (the Netherlands, WIPP, Yucca Mountain)

Another topical issue is regarding timeframes for post-closure monitoring: some approaches are indicated below:

- *WIPP:* monitoring will continue until no more meaningful data are being collected; practically, it is taken to be the same as the active institutional control period (100 y).
- *Yucca Mountain:* Undefined.
- *Belgium:* Several decades to several centuries.
- *Canada:* Several decades or centuries.
- *Netherlands:* Unknown.
- *Russia:* The regulations regarding liquid radioactive waste injection state that the contaminant plume must remain within the "mining protection zone" for 1,000 years. Consequently, it is presumed that monitoring will be undertaken for at least 1,000 y.
- *Sweden:* Not established.
- *Switzerland:* Post-closure monitoring will continue as long as it is thought beneficial to society

There is a number of techniques employed in monitoring. They can be sorted in two groups: repository and borehole based, and surface and air based. It should be noted that only the latter is not limited by equipment lifetime as the instrumentation might be replaced and upgraded.

Key parameters that are considered in most post-closure monitoring programmes are:

- Groundwater chemistry (disposal system performance)
- Groundwater pressure and water table elevation (repository impact on the environment)
- Temperature (repository impact on the environment)
- Ground elevation (repository impact on the environment)
- Seismicity, including microseismicity and acoustic emission (repository impact on the environment)
- Surface environment, including environmental radioactivity (enhancing stakeholder acceptance and confidence)
- Human activity (safeguards)

Final considerations

Post-closure monitoring should only commence after answering three basic questions: why, how to, and for how long? The disposal community has not arrived at a consensus in this matter. Thus, it should continue to search for consensus in terms of answering these questions with full respect to potential different national approaches.
Because geological disposal systems are not expected to require active safety control, monitoring is expected to (i) provide an understanding of recovery and stabilization trends in the geological environment surrounding the repository, after baseline characteristics have been determined, and (ii) contribute to waste retrieval and to the provision of post-closure information needed by society.
Post-closure monitoring tended to be seen as unnecessary and even unrealistic: it might be counterproductive if there are compromising barrier functions. On the contrary, it may be of value to reassure non-expert stakeholders of the safety of the facility. Finally, there is little evidence of statutory requirement for post-closure monitoring, but this may be introduced in the future in response to societal demands or currently unforeseen techno-scientific evolutions ???.

There was a recurrently expressed perception that public and stakeholder expectations are likely to focus on environmental monitoring, both for operational management of the facility and for long-term post-closure safety.

The closure of a disposal facility should also include the sealing of the boreholes drilled in its vicinity, including those used for monitoring. However, this will not take place if clear reasons are identified for post-closure monitoring exploiting those boreholes: shall the facility be then considered as closed?

Ideally, specifically when technical reasons exist, the post-closure monitoring project and the selection of adequate parameters should be designed in the facility baseline monitoring stage in order to ensure required continuity in terms of gathering the input data. In this sense, postponing a decision on post-closure monitoring in general and selection of monitored parameters in particular might prove counter-productive if technical reasons exist. Vice versa, when addressing societal demands, a regulatory decision or a request for the demonstration of steady state conditions relevant to the monitoring project might be effectively launched during the closing stage of the facility.

References used:
1. Torata S., et all. Technical Report RWMC-TRE-04004
2. Bergmans A.: Repository Monitoring as a Socio-technical Activity, Abstract 12229, WM 2012
3. White M.J., et all,: Techniques for Post-Closure Monitoring, NIREX 2004

Discussion Notes

It was noted that the Modern (EC FP7) workshop in March 2013 will probably give much information on this topic.

7. Local communities' position on the preservation of knowledge and memory of radioactive waste management facilities

Meritxell Martell, Merience Strategic Thinking

Claudio Pescatore and Claire Mays, NEA

The OECD/NEA Radioactive Waste Management Committee Project on "Preservation of Records, Knowledge & Memory Across Generations" (RK&M 2011-2014) explores and aims to develop guidance on regulatory, policy, managerial, and technical aspects of long-term preservation of RK&M (NEA, 2011).

Another NEA RWMC working party, the Forum on Stakeholder Confidence (FSC) proposes to contribute to this international project from the perspective of building a sustainable relationship between a facility and its hosts. Indeed, local communities and regions have expressed their interest in preservation of RK&M and may become long-term actors in this endeavor (NEA, 2011). Traditional actions for oversight and monitoring, preservation of information in archives and passive markers, are now complemented by the active participation of local communities and elements of reversibility and retrievability in repository projects (Pescatore & Mays, 2009). In this light, the FSC undertook a study analysing the roles of local community and civil society in RK&M, through a survey and a review of FSC literature.

This presentation focuses on reporting the results of a survey on monitoring and preserving RK&M that was conducted in July 2012 with FSC members to identify local communities' position on the preservation of knowledge and memory of radioactive waste management (RWM) facilities. Seventeen respondents, including regulators, implementers and governmental institutions, from eleven countries, replied to the brief survey. Apart from the first two general questions that focus on candidate communities for siting the RWM facility, the rest of the survey deals with monitoring and the preservation of memory. The specific questions submitted to the FSC members were:

1. Your programme may not have specific local communities in view at this time; in that case, please share any general information that is pertinent to local or civil society stakeholders.
2. My national programme has specific candidate or nominated site communities at this site.
3. Are local communities in your country asking for monitoring of the future RWM facility?
4. If yes, in which areas?
5. If yes, on which time scales?
6. Are local communities in your country showing interest in the issue of preserving RK&M of the RWM facility for time periods beyond closure?
7. Do any actors in your national context acknowledge that local communities could play a role in monitoring and RK&M preservation?
8. If yes, which actors?
9. Are there any documents in your country dealing with monitoring or RK&M preservation for RWM facilities that consider the point of view of local communities?

According to the preliminary results on questions 3 and 4 regarding monitoring, slightly more than two thirds of the responses indicate that local communities in their countries ask for monitoring of RWM facilities. In most countries, monitoring demands refer to environmental monitoring in the first place and monitoring of socio-economic impacts. Epidemiological monitoring is considered by less than one third of respondents whilst monitoring of institutional processes and players is seldom requested.

On time scales (question 5), communities seem to demand monitoring mainly during the short and medium-term, i.e. pre-operational phase to a few hundred years after repository closure. In contrast, monitoring in the post-operational phase is hardly ever mentioned by survey respondents.

Regarding question 6 of the survey, more than half of the answers indicate that there is an interest in local communities on the issue of preserving RK&M of the radioactive waste management facility for time periods beyond closure.

When asked whether any actors in the national context acknowledge that local communities could play a role in monitoring and record knowledge and memory preservation (question 7), the responses are positive in almost two thirds of the cases.

According to the respondents, the types of actors (question 8) that acknowledge that local communities could play a role in monitoring and record, knowledge and memory preservation vary greatly depending on the country. In some cases, the implementer is regarded as the main organisation acknowledging the role of local communities in preserving records, whilst in others, the emphasis is given to the municipal level (e.g. municipal authorities, local population, local partnerships), the governments or the regions.

Some of the participants declare that also other organisations, like industry, the regulatory body, academics, researchers and/or NGOs, recognise the active role that local communities can play in this area.

Finally, for the last question (question 9), only 7 out of 17 survey respondents indicate that there are specific documents in their countries dealing with monitoring or RK&M preservation for RWM facilities that consider the point of view of local communities.

These preliminary results will be complemented with a number of interviews with FSC members and external stakeholders to explore further local communities' demands and confidence in the preservation of RK&M.

Some references to the role of local communities in maintaining memory and monitoring is found in the theoretical work and country citations in the FSC literature (NEA, 2007, 2008, 2010; Pescatore and Mays, 2009). Indeed, local communities facilitate the task of maintaining memory (Pescatore and Mays, 2008).

Proposals made by local stakeholders include science museums, visitors' or communication centres complementing the radioactive waste management facility, interlinking the cultural design features of distinctiveness, understandability and memorialisation (NEA, 2007). There is also an emerging role for local communities in local stewardship, which involves active oversight in perpetuity, the preservation of options and the responsible transfer of unavoidable burdens (NEA, 2008).

The challenge is to design and implement a facility which becomes part of the fabric of local life and even something of which the community can be proud (Pescatore & Mays, 2009) and that provides added cultural and amenity value across generations. As countries advance in the implementation of underground repositories, the extent to which local communities can contribute to maintaining the memory of a repository will remain a subject for discussion and development in the coming years.

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Discussion Notes

L. Aparicio noted that it had been said most respondents distinguished between monitoring and memory. It was asked if France was one of those who made this distinction.

M. Martell replied that this distinction was partly a result of how the question was phrased. Only France stated that both were considered as one thing.

L. Aparicio added that Monitoring and RK&M preservation cannot be seen as separate, but at least in the mind of technical people they seem to be separated.

C. Pescatore noted that there did tend to be a distinction made between RK&M preservation and monitoring. General attitudes had moved away from the notion of 'total closure' – that is, sealing the repository and then leaving it without any monitoring whatsoever – but this has yet to develop with RK&M preservation. The results of monitoring will become part of RK&M preservation

8. Monitoring activities after closure of geological repositories

Mikael Jensen, Consultant

Introduction

Post-closure activities are measures that, by definition, are to be taken after the potentially very long period that covers all the final steps in a repository programme. It may therefore seem natural to postpone both the discussions and the relevant decisions to a later stage. However, in the Swedish voluntary siting process, questions covering all aspects of the programme are discussed thoroughly at every step in the process.

The presentation is, in part, based on a presentation I made at a meeting in 2001 together with Petra Wallberg from the former Swedish Radiation Protection Authority. Although some of the projects may have changed since the presentation, the suggestions are general and I believe that the conclusions are still valid and hopefully will stimulate discussion.

Post closure monitoring for radiation protection

The dilemma
In the eyes of stakeholders, any monitoring in the post-closure phase has the potential to contradict the basic objective of geological disposal, which is to create a highly reliable multi-barrier system, licensed by responsible authorities and found to have the capability to isolate waste for thousands of years, independent of active support.

In the eyes of some, there is a need for a guarantee in the form of a monitoring program. To others, however, a monitoring program leads to an inescapable inference that it is in place to compensate for a lack of safety in the repository, and that it would therefore be wrong to close the repository in the first place. Another conclusion that can be foreseen is that if monitoring is necessary after closure, it would also be necessary for thousands of years until most of the radionuclides in the waste have decayed.

In spite of these complications, however, it cannot be ruled out that the societal process may require a radiation protection monitoring program in some form. The Swedish voluntary process requires the consent of local municipalities, and the outcome of a societal agreement can in principle contain any provision that will favour and promote the process.

The monitoring program

It may be unknown to many local stake-holders that Sweden has an extensive environmental monitoring program. In the vicinity of the nuclear power plants, an environmental monitoring programme has been carried out for the past 20 years. Results from these monitoring programs are reported routinely within international conventions such as

The so called Waste Convention, Ref. [1]
The EURATOM treaty, in accordance with articles 31, 35 and 37, Ref. [2]
The HELCOM convention ... Ref. [3]
The OSPAR Convention ... Ref. [4]

In addition to these, reporting of monitoring is necessary in connection with activities on a case-by-case basis as required by a number of other national regulations, European Community directives, and other conventions, such as:

The EC directive on environmental impact statements Ref. [5] (Council Directive 85/337 and 97/11); and
The Espoo Convention Ref. [6]

There is thus a considerable body of reported monitoring available. A possible development is that some of this will be directed to the concerned communities, now or in the future. Another possibility is that the existing monitoring program will be modified in order to fit the requirements of the concerned municipalities and other stakeholders.

Discussion Notes

The point was raised that the examples M. Jensen had discussed were of background or baseline monitoring, and did not make specific demands for post-closure monitoring of repositories. Is there a connection between environmental monitoring and installation monitoring?

M. Jensen replied that his argument was that new forms of monitoring may not be necessary.

W. Ernst pointed out that Michael Foucault theorized that monitoring is a typically modern epistemological model, and will change. Do we need to take this into account?

M. Jensen agreed that this was an important point. He added that, in his opinion, monitoring was introduced at the wrong point of the discussion – we should first ask, what do we need? And then see if monitoring, or, for example, retrievability, is needed. Any requirement should be subjected to the question of *why* it is necessary. He gave the example of the terracotta army: What is the role of soldiers after the king has died? We should ask why we need monitoring, and what is the logic behind it.

9. Safeguards Update

Claudio Pescatore, NEA

In response to a workshop invitation to the IAEA, Safeguards Programme, the Secretariat received the following response:

"Thank you very much for the invitation to attend this very interesting workshop. Unfortunately I will not be able to do this because of other commitments.

I must say that the issue of the preservation of records and knowledge for geological repositories certainly requires further discussion and investigation. But currently the efforts of the IAEA Safeguards Department are more focused on pre-operational and operational phases of the life of a geological repository. At this time safeguards considerations for the post-closure phase are dealt with only on a very general conceptual basis. The logic is that because no geological repository will reach the post-closure phase before 2060 or even much later, we will have time to develop the

safeguards approach for the post-closure phase in the future. So, I think maybe now it would be premature for the Agency to give a 30-minute lecture on this issue.

Would you please keep me informed about the deliberations of your group. I would be very much interested to attend one of your future meetings.

My very best regards,

- Yuri Yurdin, Safeguards Programme, IAEA. "

Discussion Notes

C. Pescatore put it to the group that given the opinion expressed by a representative of the IAEA Safeguards programme, this connection should not be pursued further. Safeguards' aim is to check against states building up a nuclear arsenal, i.e. avoiding the transformation of countries into rogue states. Its paradigm is one of confidentiality. This clearly contrasts the purpose and paradigm of RK&M preservation. Nevertheless there does seem to be quite some overlap between both issues, so we should mention it.

L. Nachmilner added that, as a former IAEA employee, he knows there is work underway on post-closure monitoring, but that this cannot be shared.

M. Jensen said that the IAEA have been looking at this for the past twenty years – but have still to address how to manage and preserve data.

M. Buser said that the Safeguards programme should be acknowledged by the RK&M project, and it was generally agreed that it would be covered in the Menu Driven Document.

10. Plenary Discussion

C. Pescatore asked if the Safety Case (SC) was part of the safety story, or vice versa? How do we put them together? If we wish to say, "once we have the license it is safe", then it's not part of the SC but of the safety story, which is a different process with different actors. The same goes for retrieval or inadvertent human intrusion; these are not the responsibility of the regulator and the implementer.

Guarding against inadvertent human intrusion cannot be the only reason for RK&M preservation. It was remarked that in the context of the SC, there is too much focus on human intrusion as the reason for preserving RK&M. Today we know that this is not sufficient and should be refined.

For instance, the SC today does not address the issue of toxicity, the relative risks for which are country-specific. For example, in a densely populated country like Belgium, the consequences are greater than in, for example, the USA.

S. Wisbey said in defense of the human intrusion model, that as geological repositories consist of a passive multi barrier system, radio-toxicity only becomes an issue when the system will be breached due to human intrusion.

M. Jensen said that the aim was promoting awareness of past activities to ensure that future generations can make informed decisions.

J. Schröder remarked that we should perhaps distinguish between advertent and inadvertent intrusion. Focusing on advertent intrusion (e.g. retrievability) will entail different RK&M demands than focusing on avoiding inadvertent intrusion.

C. Pescatore remarked that advertent intrusion was not an operational issue, but a societal issue.

M. Jensen said that this again raises the issue of monitoring compensating for a lack of safety. He said that in Sweden, the question asked throughout the design of the repository was, 'could you put it under Stockholm?' Geologically speaking this would be impossible, but the point was that if it was really safe, then it should also be safe under a large population. Societal demands for checks become stronger.

T. Schneider said that the ICRP to be published in October 2012 has adopted a new proposal for geological disposal with oversight as the cornerstone. This includes monitoring and RK&M preservation. It is a generic recommendation, but important in terms of direction.

W. Ernst asked if there were any concepts for mobile repositories – C. Pescatore said that while the physical site could not be moved, the whole question of retrievability meant that the waste could be transported to another site, although this seemed unlikely given the costs that would be involved. M. Buser added that he did not think this would ever be a practical possibility.

W. Ernst went on to say that in Germany, the old European model of 'Final Disposal' (with a heuristic including terms such as final, eternal, …) was being replaced by 'Intermediate Disposal' (with concepts such as intermediary, dynamic, transient, …); and consequently the 'Eternal Memory' model was being replaced by one of regeneration.

M. Buser replied that taking into account the experiences with cleaning up old waste sites, the difficulty of the notion of 'oversight' is clear.

L. Nachmilner introduced a new area of discussion. He said that the aim was to enable understanding of the repository – and as not all of the sets of data created by monitoring could be kept, who would decide what data to select to keep and cull?

M. Kučerka said that this decision should be based on needs, and a new safety case should be prepared for the closure license.

J-N. Dumont added that monitoring and RK&M preservation are definitely connected: they are both about not forgetting. Stakeholders want both. He added that monitoring and safety may be in conflict in the post-closure context, e.g. if a safety barrier was to be breached in order to collect information. Andra proposes to monitor up until just above where the clay layer starts (65 meters away from the waste, so close enough for adequate data yet without influencing the safety function of the clay).

A. Rose asked if there had been risk analyses of the sites as compared to, for example, mines, and noted that there has never been a single death caused by radioactive waste. Is the risk of radioactive waste disposal not being over-analyzed?

In reaction to the presentation on safeguards, S. Wisbey said that safeguards do have a role, because they are a way to preserve information, and look to avoid intrusions into the site. This project should remain in contact with the safeguards programme, particularly as regards timescales.

It was was confirmed that there was not currently a 'point of closure' for safeguards.

M. Jensen remarked that safeguards rely on continual information, but do not have data management regulations. As long as there is a legal agreement covering safeguards, there is an obligation to comply with this agreement - we should not leave this community out, but try to get some finesse from them.

P. Ormai added that it is not clear what the Safeguards programme looks for, but it shouldn't be overlooked.

C. Pescatore reminded the group that apparently there exist already many mechanisms to keep 'some memory' alive – c.f. Thierry Schneider's study (cf. 23), or the INIS programme (cf. 33). The project is not isolated, and an RK&M preservation programme would not have to invent everything.

W. Ernst said that we should stop using regulation as a reason or as insurance. It should be remembered that the legal system is a symbolic code, the content and role of which is continuously changing and evolving. Nuclear decay, on the other hand, is a stable, physical fact. We should expect the need to be flexible to more and more changes, including the evolution of the the role of the symbolic code. We should thus think about how we can make these two codes – symbolic and physical – complementary.

SESSION 3 - RK&M, LOSS and RECOVERY

11. Introduction to the session "Records, Knowledge and Memory, Loss and Recovery"

Thomas Kaiserfeld, Lund University

Becoming aware of the likelihood, pathways and effects of loss.

This session is about the possibilities and problems of losing knowledge. How can losses be avoided? And how can we facilitate the recovery of lost records? Problems like these are in fact identified as the second of six different challenges listed by OECD's Nuclear Energy Agency (reference?). It states that: "Actions to mitigate and adjust potential RK&M loss should be evaluated and must be implemented in a transparent and cooperative fashion…"

Note that this is in stark contrast to our usual relation to waste. At this very moment there is a postgraduate conference on "trash" organised at the University of Sussex by the Sussex Centre for Cultural Studies. In the call for papers to this trash conference, it is stated that: "Trash operates as a physical and symbolic manifestation of consumer society and its associated debris; it celebrates the filthy, excessive and grotesque; and it expresses how power communicates and classifies abject bodies." Clearly, the loss of trash or waste would be beneficial from this point of view.

In this session, however, it is very different. Loss of information about nuclear waste, not to speak of loss of the waste itself, is considered to be a problem, indeed a challenge. The problem of loss and recovery of nuclear waste thus has its own dynamics. On the simplest level of analysis, there are two different forms of loss, each implying very different forms of recovery techniques. There is *physical loss* of records when they are no longer available. And there is *epistemic loss* when the physical records are available, but cannot be interpreted or understood. The abstracts of the papers in this session make me suspect that both of these types of loss will be addressed the following two hours.

But these categories can also be used to analyse the different types of knowledge loss that occur today. One language is claimed to die every day. In these cases, both physical and epistemic loss has most often occurred. This is not always true when discussing the loss of different artisan skills in our fully industrialised society. Take a skill earlier commonly spread such as carpentry. How many can today claim to posses the knowledge of how to choose a birch tree to take wood from in order to build a bedframe or an oak for a roof beam? Thus, if not lost, knowledge can transform from having been broadly spread to be carried by only a few hands. Knowledge can also jump between different social and cultural categories. In Sweden, for instance, the most prominent carriers of the knowledge of how to manage and ride horses are no longer either land-owning farmers, or nobility, but schoolgirls. And knowledge can slowly transform so that original practitioners may not be able to recognize those of today. What would Marx make of today's Marxists? What would Jesus and other prophets make of religion and its practices?

But do not despair. There are techniques to prevent and perhaps even to avoid loss, both physical and epistemic, and also to facilitate recoveries. This session deals with such techniques in three different presentations supplying a number of perspectives. The first one is provided by a geologist turned nuclear waste expert, Marcos Buser who will begin this session by suggesting a framework built on causes and combinations of causes to which we can refer throughout the workshop. Secondly, media theorist Wolfgang Ernst will analyse forms of cultural tradition where radioactivity can be viewed as a specific form of material knowledge transfer over generations. Thirdly, archaeologist Cornelius Holtorf will explain how historians and others reconstruct knowledge when records are no longer available.

12. Loss of information, records and knowledge in the area of conventional waste disposal – First Interim Report

Marcos Buser, Consultant

1. Introduction: Background, problem-setting and aim of the report

The NEA RK&M project seeks, among other things, to gain know-how and experience on loss and recovery of knowledge and memory preservation in other areas than nuclear wastes. One area with similar characteristics - and therefore rather well-suited for comparisons - is that of landfills and old industrial or disposal sites for hazardous wastes.

In view of the RK&M workshop of April 2012, our Institute was commissioned to undertake an exploratory investigation into the loss of memory - through the loss of information and records – on conventional landfills and contaminated sites of the past. This small case study aims at identifying key factors in the loss and recovery of knowledge by analyzing selected examples of landfills and

contaminated sites in Europe and other industrialized nations. As a result, findings for the handling of information, records and knowledge in the field of nuclear waste shall be gained. The work at hand represents the final report of this investigation.

2. General approach

Experience with ground water polluted by landfills and polluted sites is rather recent. During the period of industrialization in the 18th century, especially with the advent of new techniques, both energy consumption as well as the waste generated by the production and use of goods increased sharply. This development is especially characteristic of the industrialized nations of the 20th century and continues today - in a slightly altered context - in emerging developing countries.

The number of landfills and disposal sites created during one century are virtually innumerable, the possibilities to investigate the loss of information, records and knowledge accordingly vast. It was therefore necessary to narrow down the issue so that relevant processes with regard to information, record, knowledge and memory loss become visible.

A two-part methodology has been developed for data gathering and analysis. First, key factors - similar to those chosen for a study on the marking of repositories for radioactive waste (Buser 2010) - have been identified. This list of key factors was refined and expanded in the course of the investigation. Second, criteria have been established to select cases that are representative of the phenomena of knowledge loss among the full set of landfill and disposal cases (Table 1). This should allow us to draw key conclusions and identify particularly relevant points to be considered, which may also have important applications for nuclear waste disposal.

Five key factors of loss of information, records and knowledge of landfills and contaminated sites have been identified. First of all there are technical or environmental factors, such as the destruction of archives, insufficient updates or lack of records such as maps or plans, or the loss of memory of ancient disposal sites due to simple site degradation. A second group of factors are related to economic conditions, particularly the lack of funds to fulfill the requirements of synthesis of information or preservation of documents and archives. Human factors as a of loss of information, records, knowledge and memory are also very important: some factors are e.g. loss of knowledge and memory when staff leaves before knowledge is written down (e.g. retirement, change of job), ignorance or incompetence, the deliberate intention to forget about something annoying, or even voluntary criminal records and knowledge destruction. Structural factors describe structural deficiencies or factors leading to social ruptures during crisis or basic changes in the organization of administrations or companies. Another category of factors that has to be taken into account is the lack of regulation or laws with regard to how to deal with information, records and knowledge.

Finally, coupled processes play an important role. Table 1 summarizes some of the factors considered in the investigation.

	Causes of loss records and knowledge	**Primary factor for loss**	**Reference cases**
1	**Technical / environmental factors**		
1.1	Site degradation (partly also of technical installations)		
1.2	Recultivation of old disposal sites / camouflage		
1.3	No records or poor archives		
1.4	No or insufficient update of records (e.g. maps, plans)		
1.5	Loss /destruction of archives		

2	**Economic factors**		
2.1	no or insufficient budgets to fulfill the duties		
3	**Human factors**		
3.1	Loss of knowledge / memory due to personal changes		
3.2	General disinterest		

3.3	Negligence in the accomplishment of duties		
3.4	Ignorance and/or incompetence		
3.5	Haughtiness		
3.6	Underestimation of effective risks		
3.7	Misunderstanding of information and records		
3.8	Criminal activities (e.g. falsification of documents, illegal disposal)		
3.9	Deliberate restraint / manipulation of data, information and records		

4.	**Structural factors**		
4.1	Social ruptures (e.g. war, crisis)		
4.2	Structural deficiencies (e.g. lack of structural competence)		
4.3	No or poor structural continuity		
5	**Regulation / laws**		

5.1	Lack of regulation / laws		
6	**Coupled processes (e.g. ignorance and economics)**		

Table 1: Motives to be considered within the discussion on knowledge loss

3. Selection criteria for the investigation of specific cases of knowledge loss

The number of contaminated sites, landfills and facilities with materials hazardous to the environment is almost endless. It is obvious that each object has its unique history and that similarities within this large number of objects have their limits. Nevertheless, the loss of knowledge – through the loss of information and records – often has similar reasons and backgrounds that can be categorised reasonably well.

In Switzerland, there are about 50,000 sites containing pollutants arising from landfills, facilities or accidents. About 4,000 of them are considered contaminated sites (BAFU et al. 2011), of which only a very small part is regarded as in need of environmental remediation/clean-up. The majority of the contaminated sites are considered as requiring special supervision (idem).

In Germany, rather precise information is available on the number of old landfills and contaminated sites as well as the status of the environmental remediation. Currently, more than 300,000 sites of old landfills and contaminated areas are under investigation. The huge number of old deposits doesn't allow an extensive study of the loss of information, records and knowledge.
Therefore, our investigation focuses on selected case studies that show and document mechanisms for the loss of information, records and knowledge. Since sufficient material is available, the selection of case studies was driven mainly by the following considerations:

- Integration of the results of the study that was presented by the SKB at the RK&M workshop in Paris in October 2011
- Interviews with representatives of public authorities or private companies on information, records and knowledge loss concerning landfills and old waste deposits in parts of the country (e.g. canton Zurich, canton Aargau) where sufficient reliable data is available.
- Personal experience in the environmental remediation of old landfills or large disposal sites in Switzerland and Germany
- Literature study of known contaminated sites and search for specific patterns of information, records and knowledge loss

In total, more than 20 case studies were selected and briefly described. What was important for this study was to characterize what kind of information, records and knowledge was lost and how relevant the loss of that knowledge eventually was.

4. Investigations, first results, further steps

Investigations have been done by interviews with different Swiss and German state officers, experts and consultants in the area of waste disposal and clean-up activities of dumps and industrial areas. Personal experience over some decades in this field has also been included. It should be emphasized that it is hard to get really valuable and robust information. We are investigating in a nasty field where the persons in charge are prudent and closemouthed and worried that the delivered information could lead to inquiries.

In a first phase a list of potential interviewees has been prepared, all of them having long-term experience and deep insight in waste disposal and clean-up practices of dumps and contaminated areas. Some of these experts and officials were actually interviewed. More than 20 selected case studies have been considered and first conclusions could be obtained.

First of all, human weakness appears to be a determinant factor explaining the loss of information, records and knowledge. Many examples shows that responsible staff don't want to know too much about the dangers and long-term consequences of their decisions and acts. Even if the responsible staff is basically aware of negative consequences, no action is taken to prevent further damage.

Orders and established practices are followed without question. A good example of this practice is the case of a former US military camp in southern Germany. Once a week, fuel for tanks and other military vehicles were delivered by rail with cistern wagons. However, the storage reservoirs on site

were limited. Over decades, fuel excesses were directly discharged into the soil. After the army retired from site, geological investigations showed very high fuel contaminations above groundwater. A historical enquiry brought to light the described fuel discharge practice. The site was later cleaned up with very high costs.
Human factors appear to be determinant for knowledge and memory loss. A Swiss cantonal officer describes the practice of waste management in the Canton of Zürich as an active process of memory loss since environmental pollution is not acute. The authorities are doing as much as necessary. Nothing more.

Lack of regulation is another important factor of knowledge loss. There are many examples that show that industries are doing only as much as regulators request. The loss of information is generally high in these cases, because insufficient records are assured. When responsible staff retires or leaves the company, information is generally definitively lost.

Economic factors are quite important. Recording is simply not possible with low or inexistent budgets. Much information on waste disposal sites was lost because of lack of finance for recording. This problem appears in practically all investigated cases.

Technical or environmental factors seem to have the smallest impact of all analyzed factors. Knowledge and memory loss can sometimes be related to the loss of archives, as it could be shown in the cases of the Bonfol and St-Ursanne waste disposal sites. But the destruction of these archives is directly related to the inability of the responsible state officers to recognize the value of the documents that were freed for annihilation.

In the next months, information should be completed by other interviews with officers of cantonal agencies. Furthermore, experience of some known case studies as the Love Canal (Niagara Falls, USA) will be integrated in the exploration. A first draft of the report will be available to the end of 2012.

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Bafu & BfS (2011): Umweltstatistik Schweiz in der Tasche 2011 Bundesamt für Umwelt BAFU, Bundesamt für Statistik BFS

Discussion Notes

M. Martell asked if the regulations themselves were an important factor in memory loss.

M. Buser replied that environmental laws that outline RK&M preservation are rather recent, and also mentioned disinterest (not a popular theme - both tricky and boring) and lack of knowledge with the regulator. It is also politically difficult to strain large economic players .

M. Buser said that he would talk about oblivion as well as preservation – that is, we have to understand the motives behind oblivion. It was added that oblivion, which implied the unconsciousness of action, should be separated from the suppression of memory – that is, the willful elimination of memory.

T. Kaiserfeld noted that all of the factors covered in the analysis were human factors – so, people are determinant.

13. Half Lives Of Knowledge: A Media-Archaeological Point of View

Professor Wolfgang Ernst, Humboldt University

In the discussion of how long knowledge can be expected to last, and in what form, for the immediate future the human factor seems to be determinant (Marcos Buser). But regarding the

challenges and chances of maintaining knowledge across emphatic temporal distance, and in respect to the options of reconstructing lost or damaged knowledge, an "archaeological" perspective (in its various meanings ranging from the academic discipline up to Foucault's *Archéologie de Savoir* and even media-archaeology) is useful which focuses on the non-human agencies of knowledge traditions. Media theory here is helpful since it addresses both the philosophical (epistemological) and the engineering (techno-mathematical) questions involved. The present focus is on nuclear energy both as medium and as subject of knowledge reflection, with a special accent on the delicate relation between technology and time.

For the analysis of the techno-logics of knowledge tradition, a focus on both the material (technical) forms which are subject to physical entropy and on the immaterial (logical), almost time-invariant codes of transmission is required: the physical *versus* the symbolical mode, material embodiment ("markers") *versus* logical implementations (archives). In this context "symbolic" does not refer to symbolism in its iconological sense of metaphorical meaning (such as the much discussed "markers" on nuclear waste sites[6]), but to discrete characters in coding information (ranging hitherto from alphabetic letters and Arabic numbers up to the binary code of Zeros and Ones embodied as Low and High voltage levels in electronic computing). The current shift from material memory as cultural premise to techno-mathematics as the dominant form of cultural communication corresponds with a different kind of tempor(e)ality: cultural memory once intended for eternity transforms into an on-going practice, economy and aesthetics of short-term intermediary storage: repeated data migration, "the enduring ephemeral"[7].

In every act of cultural transmission, there is a symbolical (code) level on the one hand which is time-invariant, and an entropic, temporally decaying ("historical") physical reality on the other. Let us take as an example for symbolical tradition the transmission of Euclid's *Elementa* from Greek antiquity to the European Renaissance *via* Arabic translation (intermediation). Here, the very name (the medium) is the message: *Elementa* is the name for letters (the ancient Greek alphabet) and numbers, which serve as the concrete symbolic medium of transmission.[8] The subject of this work, mathematical geometry, itself claims metahistorical truth (the Platonic "anamnestic" knowledge), while the physical embodiment of this symbolic knowledge, e.g. ancient book rolls, are subject to decay. Such implicit knowledge traverses cultural history according to temporal laws of its own. It is self-repetitive, close the model of "memetics" (a kind of cultural memory gene, as defined by the evolutionary biologist Richard Dawson).

For the interplay between material and symbolical media of knowledge tradition, let us look closely at a painting which sums up these conflicting regimes: Anton Raphael Mengs' painting *Allegory of History* (1772/73) on the ceiling of the *Stanza dei Papiri*. This room is an almost epistemological

passage, since it links the Vatican Library (the Gutenberg Galaxy of alphabetic characters) with the Vatican Museum (material cultural memory). Mengs' allegory thus both topologically and thematically represents the dichotomy between material and symbolical objects and records of cultural transmission: physical entropy *versus* symbolical (ahistorical) invariance. Museums, libraries and archives - all three memory agencies which act in the Vatican context of Mengs' allegory - are agencies of cultural transmission across time. The dramatic setting of Mengs' allegory is about conflicting tempor(e)alities which are at work with cultural tradition: Chronos (physical, material entropy) *versus* Clio (symbolic coding).

There is another 18th century allegory of the mechanisms of cultural transmission, the frontispiece of Lafitau's publication *Moeurs des sauvages Ameriquains* (1724). This image confronts archaeologically silent, but enduring material artefacts with the discursive, but transient murmur of historiography. The viewer is confronted with

[6] See the OECD Radioactive Waste Management publication *More than Just Concrete Realities: The Symbolic Dimension of Radioactive Waste Management* (2010).

[7] See Wendy Chun, The Enduring Ephemeral, or The Future Is a Memory, in: Erkki Huhtamo / Jussi Parikka (eds), Media Archaeology. Approaches, Applications, and Implications, Berkeley / Los Angeles / London (University of California Press) 2011, 184-203.

[8] See Michel Serres' writings on the history of sciences.

<...> the encounter of writing and time in a closed space littered with "vestiges" coming from both Classical Antiquity and the New World. One holds the pen, the other the scythe, <...> which approach each other without ever touching, asymptotically. History deals with relics which can be seen, and seeks to supply explanations; ancient *things* <...> have become mute throughout the degradation owing to time <...>.[9]

Archaeology deals with gaps; historical discourse is made to fill this up. Michel de Certeau enhanced his interpretation by drawing the configuration of Chronos and Clio abstracted to a diagram where the supposed prolonged lines of the curved scythe and the linear pen become vectors.[10] Directly deciphered in terms of mathematics, the pen-line (as x-axis, the abscisse) becomes the asymptote of the scythe as hyperbel (on the y-axis). There is no point where the function touches or traverses the x axis itself: no convergence between material ("historic") and symbolic ("historiographical") phenomena of time. In Lafitau's allegorical illustration, Chronos' scythe indicates devastation with time - in fact „noise" which happens in the temporal channel of transmission (to rephrase it in terms known from transmission engineering).[11] Such material loss of information is compensated by the female allegory of Clio „writing" history: copying of symbolic letters is an almost lossless technology of tradition.

Cultural tradition which is normally described in historiographical and hermeneutic terms can thus be re-phrased in terms of signal-based communication engineering. Shannon's techno-mathematical theory of communication (1948/49) which concentrates on media channels can be extended to the mechanism of emphatic cultural tradition as such, allowing for the calculation of the probabilities of materially embodied and symbolically encoded transmission of knowledge within the temporal domain (understood here in reverse to space-bridging communication). Communication with extra-terrestrial intelligence and even the use of "cultureless" signals may serve as a model for transmission of knowledge into a post-historical future.

"Knowledge" in the RKM *Glossary of Key Terms* is defined as "the ability to understand and utilize the available data, information and records". The reader here obviously is meant to be human, but what if future readers are rather "robot historians"[12]? Let us converge this definition with Karl Popper's "third world of knowledge"[13] as an inherent, physically or mathematically implicit form of knowledge in latency, waiting to be recovered or even self-revealing (much beyond Polanyi's rather sociological notion of "tacit" knowledge). The alternative model to knowledge tradition thus is co-origin[14], that is: the emergence of a same (or similar) knowledge anew at any given time, independent of its culturally transmitted knowledge, as indicated e. g. by the monumental formulaic "$m = E/c^2$" inscription at the COVRA nuclear site, The Netherlands, which will faint parallel to the nuclear half-time, but implicitly remain intact as natural law.

Radioactive memory represents a special case demanding for more radical, daring theories and "radio"-based operations of knowledge transmission which is not limited to human understanding exclusively any more, taking the nuclear time clock itself as point of departure - time without a knowing subject, a kind of temporal information within the emitting electro-magnetic radio waves themselves. Depositories of radioactive waste embody a kind of "hot" nuclear clock indeed; the half-time values of radiation decay of uranium itself may serve as a long-time counter which - communicated *as* and *by* radio waves - is the message of the nuclear medium. In the case of the copper discs attached to both Voyager space satellites (launched in August and September 1977) which was intended to carry messages from the earth to extra-terrestrial intelligence, the gold-protected aluminium record cover itself has been not only inscribed with diagrams to visually

9 Annette Lavers (rev.), on: Michel de Certeau, Writing versus Time, in: Rethinking History. Time, Myth, and Writing, ed. M.-R. Logan / J. F. Logan, New Haven: Yale French Studies 59 (1980), in: History and Theory XXII, 3 / 1985, 330f.

10 Diagrams (as defined by Charles Sanders Pierce) in fact turn out to be the most appropriate form of knowledge tradition, since they do not depend on iconological representation while at the same time being evidential for reasoning.

11 Claire Mays (NEA), in fact, points out that the scythe is not just a weapon but an agricultural tool as well; invasive cutting of agricultural plants is the condition of re-growing it. The scythe thus gives an extra sense to the dialectics of forgetting and re-generation (without memory).

12 As suggested by Manuel De Landa, War in the Age of Intelligent Machines, 1991.

13 See Chapter 3 ("Epistemology Without a Knowing Subject") of Karl R. Popper, Objective Knowledge, Oxford 1972.

14 "Gleichursprünglichkeit" in German, as coined by Martin Heidegger's philosophy.

communicate information about human civilization but contained (and still contains, on its voyage in outer space) some ultra-clean Uranium 238 with a radio activity of about 0,00026 mircocurie. Its steady decomposition into its "daughter isotopes" turns it into a kind of radio-active clock, with a half live of about 4,51 billion years. An extra-terrestrial intelligence, by measuring the remnants of this sample might calculate and infer the time which has passed since that sample of Uranium had been fixed to the record cover.[15]

Let us replace the humanistic trust into secure transmission of knowledge by the notion of improbabilities of transmission and by stochastic configurations where the physical radioactive medium itself is the temporal message. The very notion of "record" is questioned here; waste lands require the cold gaze of the techno-mathematical archaeologist to be detected.

Discussion Notes

C. Holtorf picked up on the model of communicating with 'non-human' intelligence. He asked if it was also our responsibility to communicate with future machines.

With all recording of radioactive signals – there is information and noise. Future receivers of our information will experience the same thing. A mathematical model may now be able to separate signals from noise.

C. Pescatore noted that in the archeology of prehistory, as there are no documents to provide cross-reference, the context of the find becomes the reference. So, if one stone which looks like an arrow head is found, it may well simply be a stone – but archeologists can recognize the signs of a place that was used for making stone tools. Providing physical cross references will aid understanding into the long term.

W. Ernst underlined his idea that waste could be the subject, rather than the object of knowledge. In the Netherlands, there is a site with '$E=MC^2$' painted on the side, which fades at the same rate as the half life of the radioactive waste.

C. Holtorf mentioned that Cronos, the figure W. Ernst referred to in his talk, who has been used to represent the decay of time, carries a scythe – Ernst had referred to this as a weapon, but it is also a tool.

Michael Jensen asked if mathematics was truly objective and universal, in the Platonic view, or made by man ? Referring to Thomas Kuhn, he pointed out that absolute objectivity is a dangerous notion – paradigms change, knowledge is dynamic. Our knowledge of e.g. radiation today is based on quantum physics, but as we all know science is also dynamic.

15 Carl Sagan et al., Signale der Erde. Unser Planet stellt sich vor, München / Zürich (Droemer & Knaur) 1980, 41.

14. A Comment on Knowledge Recovery: "How we today can make things easier for historians/archaeologists of the future"

Cornelius Holtorf, Linnaeus University, Kalmar, Sweden

The brief set for me:

1. *In cases where archives, records and monuments are not available:*

   How do historians/archaeologists reconstruct knowledge?

2. *Would the purposeful creation today of artefacts disseminate knowledge and memory about geological disposal sites?*

Clarification on archaeologists and historians:

Although historians and archaeologists to some extent work with different source material and ask different questions, they both translate the past into the present. Although I am an archaeologist myself and am more familiar with archaeology, in this document I do not make any strict distinctions between both academic fields and do not think that they are warranted in a long-time perspective.

I. Some principle considerations about the questions at hand

Knowledge Recovery

- Knowledge is more than data and facts (which, once lost, can be recovered by others). Knowledge is also more than metadata and "the ability to understand and utilize the available data, information and records" (as the RK&M glossary has it)
- Future historians/archaeologists need to reconstruct even the broader understandings that provide a cultural context for a given knowledge and its utilization.
- Future generations cannot make informed decisions based exclusively on data, metadata and the ability to understand and utilize them, but they also need to *understand the overall context within which data and metadata make sense to us and how it relates to our norms and values*.
- Such larger understandings, once lost, cannot easily be recovered. RK&M is therefore not simply a matter of loss & recovery of data, facts, meta-data and the ability to understand and utilize them. The task at hand is therefore even more complex and more daunting.

"How today we can make things easier for historians/archaeologists of the future"

- How do we know that there will be historians/archaeologists in the future? (Academic history is only about 250 years old, with their earliest predecessors some 2,500 years ago.)
- What does it mean to make things "easier" for them? What will be their aims? (Even today most historians/archaeologists do not think they should recover ancient knowledge or the ability to utilize it.)

In cases where archives, records and monuments are not available…

- It is not likely that at any point in the human future there will be no *archives, records and monuments* available at all, as they exist for all parts of the human past (mostly as part of the archaeological record)
- It is possible that at some point in the future no relevant *archives, records and monuments* will be available. But how do we know what future historians/ archaeologists will consider relevant to reach their aims?
- It is possible that at some point in the future no primary (intentionally prepared) *archives, records and monuments* will be available. This refers to sources we would like to remain available in the future, although we may eventually be proven wrong about their significance. Still, this seems to be the key issue. I was asked to comment on in my presentation.

How do historians/archaeologists reconstruct knowledge?

- Historians/archaeologists do not necessarily reconstruct anything. They make sense of the past and its remains in the present (creating meaning).
- For example, the field of archaeo-astronomy encompasses a number of theories about the astronomical knowledge and utilization of certain prehistoric monuments (like Stonehenge) for astronomical observations in the distant past. But it is unclear to what extent these theories are in fact reconstructions. In a historical perspective, these theories rather appear to be constructions reflecting a particular way of making sense of certain prehistoric monuments. Just like prehistoric monuments were interpreted in a variety of different ways in other ages, archaeo-astronomy reflects the logic of the space age by which ancient technologies acquire astronomical significance and distant civilizations are being awarded advanced abilities and intelligence.

II. Some lessons for what future historians/archaeologists may think is particularly interesting to study

Some premises

- Some *historical* records will always be available (as long as there is writing)
- An *archaeological* record will always be available. *"Nothing is more permanent than a proper posthole"*(Carl Schuchhardt 1904).
- In the present context, I do not take into consideration the accessibility of sources in terms of the language being used (medium of communication) and in terms of physical preservation as both are rather complex questions that are studied in detail by others elsewhere.
- In the following, I make the assumptions that future historians/archaeologists will think like presently living historians/archaeologists (I know of no substantial study containing long-term predictions of how historians/archaeologists are going to think in the future).
- I assume also that interest by future historians/archaeologists will increase the chance that future generations will understand from the source material they are working with what exactly we have left behind in depositories of nuclear waste, how we left it, and why we left it.

Future historians/archaeologists may think that it is particularly interesting to study…

1. Relatively large topics on which there are many different kinds of sources that confirm and complement each other, together providing a comprehensive cultural context.

   For example, there has long been a wide-spread interest among historians/ archaeologists in ancient Mesopotamia, ancient Rome; World War II and the Cold War about which there are many different kinds of sources with complementary and overlapping information. On the other hand, there is little interest among historians/archaeologists in the person of Jesus (only one source).

   Lesson: leave complementary and overlapping information in many different kinds of forms and locations connected to the main processes and events of our age, including private correspondence of employees, the project's financial details, lunch remains, archaeological sites, bodies…. Instead of leaving the same records in several archives or several artefacts in the same location, create wide-spread redundancy and variation which will make duplicated

   information more reliable (confirming each other) and any singularity more interesting (sticking out).

2. Individual topics that are linked in some way to particularly exciting mysteries and enigmas.

   For example, there has long been a wide-spread interest among historians/ archaeologists (not always professionals or academics) in Stonehenge, Atlantis, Jesus, the Holy Grail, Vikings, Hitler…

Lesson: connect information with exciting mysteries and enigmas around the world.

3. ”Closed finds”, i.e. archaeological assemblages that were deposited simultaneously, subsequently remained undisturbed from interference, and therefore have the character of a time capsule.

   For example, Roman Pompeii and Herculaneum, buried in AD 79 by several meters of ash and pumice from the eruption of the volcano Mount Vesuvius, represents a fascinating snap shot of life in Roman Italy.

   Lesson: information kept in one place should be sealed in a way so that its quality as a closed find is maintained over long time periods and clearly recognizable to any future researcher. It is conceivable to deposit a series of such closed finds that are to be opened in regular intervals, e.g. every 100 years.

4. Those sources whose containers or media are themselves extraordinary artefacts providing additional qualities, e.g. through the use of precious materials, through original design, through rich ornamentation, or through the elaborate craftsmanship that went into them.

   For example, the Book of Kells is a very well-known and extensively studied Medieval manuscript containing among others the four gospels of the New Testament. Today it is known first and foremost for the calligraphy applied to the text.

   Lesson: at least some of the containers and media of information should be extraordinary artefacts providing additional qualities that may attract interest in the future.

Conclusions

1. *In cases where primary archives, records and monuments are not available*

   How do historians/archaeologists reconstruct knowledge?

   ANSWER: They will make their own sense of the sources they have at their disposal.

   Try and make it interesting for them to study!

2. *Would the purposeful creation today of artefacts disseminate knowledge and memory about geological disposal sites?*

   ANSWER: Not necessarily. For example, the Japanese tsunami markers were known and correctly understood by some. But they nevertheless did not lead to any action that reduced the amount of damage caused by the tsunami in Japan in 2011.

Discussion Notes

W. Ernst distinguished between archeologists and historians, saying that whilst historians make sense of findings, an archeologist is more akin to the natural sciences, in that the aim is describe and decode what is found. C. Holtorf rejected this view, favoring the idea that archeology was a branch of history with a different methodology.

15. *Plenary Discussion*

It was suggested that ‘lost’ knowledge is not lost if it exists somewhere, in some form.

The possible usefulness of temporary oblivion was discussed - using the example of Tutankhamen’s tomb, which was remarkably complete when it was rediscovered in 1922. The paradox was pointed out here – that whilst it was forgotten for a long time, it was also searched for for a long time.

A. Rose pointed out that Tutankhamen’s tomb had in fact been robbed twice and then resealed. So, the dire warnings of disfigurement and painful death had not worked – there is nothing more attractive than a door which says ‘don’t open’.

Subsequently, it was asked whether making a disposal site interesting, as was suggested by C. Holtorf, will not encourage people to open it.

C. Pescatore remarked that throughout this project, we have gone past the idea of warning people to stay away. We give future generations information and if they want to go in, then that is their decision – all we can try is for them to want to make sense of what is there by means of the messages we try to transfer.

With regard to the means of making a site interesting, it was also generally pointed out that the practicality of this needed to be tested against the natural decay and movements of population and culture implied by the medium and long term the project was concerned with.

With regards to the notion of the 'intrigue' of the past, H. Gordon-Smith suggested that language survival may not be a concern for the preservation of RK&M, as old languages are in themselves intriguing. Furthermore, there are few more thoroughly documented phenomenon than modern world languages – there is very little danger of this becoming 'lost'. Simply writing the information in modern English may well be sufficient.

W. Ernst raised another example of the intrigue of history – that of the Vatican Archives, which were the subject of centuries of conspiracy theories – but when they were opened up, they were found to be incredibly banal. He proposed that radioactive waste repositories are not capable of extending our cultural models of understanding – they are the limit of that understanding.

T. Kaiserfeld summarized some of the main points of the session:

- The main danger is epistemic loss;

- We shouldn't only think about humans like ourselves as recipients;

- We should consider directly using physical phenomena as communication media themselves.

PROJECT UPDATE

16. The RK&M Bibliographic Study

Richard Ferch (consultant to the RK&M project)

A consultant was engaged to provide a revised set of abstracts to the existing bibliography of the RK&M project (previously compiled by Anne Claudel for the project); to compile responses to a standardised set of questions for each reference in the bibliography; and to analyze the responses and present them to the RK&M working group.

Progress has been delayed this summer for health reasons, but the work is now getting back on track. The scope, at least initially, has been restricted to the conference proceedings, reports and dissertations categories in the bibliography. The primary focus has been on the questions and the responses to the questions, in order to help with the goals of identifying gaps and suggesting topics and priorities for further work.

The initial questions, based on the analysis presented by J. Schröder in October 2011 with some additions, were presented at the April 2011 workshop. Since that time, the questions have been recast into closed form (i.e. with yes or no answers). This makes analysis of the answers more amenable to automated tools such as a spreadsheet program. The resulting question set, a total of 61 closed-form questions plus one open-form question for additional comments and aspects not covered in the main set, is at the end of this status report.

In compiling total counts of responses to the questions, weights may be assigned to each document according to the document's perceived relevance to the project. To date, the question responses for 8 directly relevant documents (assigned weight 1) and 10 partially relevant documents (assigned weight 0.5) have been transferred to a spreadsheet and totalled. The weights assigned to each document can be changed easily; the numbers chosen were intended to help avoid losing sight of the

"core" documents in the larger number of off-topic documents in the bibliography in which preservation of RK&M for waste disposal purposes is only mentioned tangentially.

One category of documents that has not yet been included is the large number of documents relating to the analysis of markers required for the WIPP program in the USA. Despite this omission, the WIPP program has still been represented in the analysis, as a number of the documents that have been included review or summarize much of the work done for WIPP. Since there is a large number of detailed documents on this specific project, as opposed to the smaller number of documents available for most other projects, and since there is considerable overlap between them, at least at the level of our standard questions, we may wish to assign a lower weight to each of these documents even though they are directly relevant to the RK&M topic, in order to avoid biasing the results towards that particular project.

The most useful information from a numerical analysis of this type is likely to be the identification of areas that have not been widely addressed in the documents in the bibliography. Preliminary analysis of the responses for the documents assessed to date has pointed out a number of areas that have received relatively less attention, some of which may be considered as candidates for further work. These include the question of establishing costs and funding for activities that may be required for ongoing preservation of RK&M; the role of NGOs in RK&M; the role of monitoring in both creation and preservation of RK&M; security and safeguards as motivations for preserving RK&M; questions about actions that might be taken in the long term to preserve RK&M and/or to mitigate loss of RK&M; and the role RK&M preservation might play in ensuring the existence of future expert knowledge needed to help preserve and interpret factual data and metadata in the longer term. A number of these topics are already being addressed under other agenda items at this meeting.

The Question Set

Note: Responses in the right-hand column should be “yes” or “no” (“no” includes “not applicable”). It is possible, and in many cases expected, that there will be multiple “yes” answers within a category, i.e. the questions are not intended to be mutually exclusive.

I. WHEN	
I.1. Does this document describe or discuss preservation of R, K & M for purposes of the very short time scale (i.e. to support currently ongoing waste management activities)?	
I.2. Does this document describe or discuss preservation of R, K & M for purposes of the short time scale (i.e. to support operations up to the time of closure)?	
I.3. Does this document describe or discuss preservation of R, K & M for purposes of the medium time scale (i.e. during a period of institutional control or oversight post-closure)?	
I.4. Does this document describe or discuss preservation of R, K & M for purposes of the long time scale (i.e. after institutional oversight may no longer exist)?	
I.5. Does this document describe or discuss actions to preserve R, K & M that would be carried out in the very short time scale?	
I.6. Does this document describe or discuss actions to preserve R, K & M that would be carried out in the short time scale?	
I.7. Does this document describe or discuss actions to preserve R, K & M that would be carried out in the medium time scale?	
I.8. Does this document describe or discuss actions to preserve R, K & M that would be carried out in the long time scale?	
II. WHY	
II.1. Does this document mention or discuss preservation of R, K & M in order to comply with legislation or regulation, either existing or proposed?	
II.2. Does this document mention or discuss preservation of R, K & M in order to support preparation for or the conduct of licensing review of the disposal system?	
II.3. Does this document mention or discuss preservation of R, K & M in order to support preparation for or responding to unforeseen events during construction and operation?	
II.4. Does this document mention or discuss preservation of R, K & M in order to support reversibility or retrievability?	
II.5. Does this document mention or discuss preservation of R, K & M in order to prevent or reduce the likelihood of inadvertent intrusion?	
II.6. Does this document mention or discuss preservation of R, K & M in order to support communication and public acceptance of a repository?	
II.7. Does this document mention or discuss preservation of R, K & M in order to support security measures?	
II.8. Does this document mention or discuss preservation of R, K & M in order to support safeguards or non-proliferation measures?	
II.9. Does this document mention or discuss preservation of R, K & M in order to maintain knowledge of heritage?	
II.10. Does this document mention or discuss preservation of R, K & M in order to meet ethical obligations?	
II.11. Are the possible consequences of loss of R, K & M discussed or described in this document?	
II.12. Does this document discuss or describe measures to be taken to assist in mitigating or compensating for the potential effects of loss of R, K & M?	

III. WHAT	
III.1. Does this document discuss retention of expert knowledge (e.g. in order to maintain competencies)?	
III.2. Does this document discuss retention of factual information (design data, drawings, technical information about contents)?	
III.3. Does this document discuss retention of meta-knowledge (explanatory or contextual)?	
III.4. Does this document discuss establishment or preservation of symbolic records and markers such as warning signs?	
III.5. Does this document describe the specific information that should be preserved (e.g. minimum data requirements)?	
IV. WHO	
IV.1. Are any of the R, K & M preservation measures described in this document intended to be carried out by experts (scientists, engineers)?	
IV.2. Are any of the R, K & M preservation measures described in this document intended to be carried out by waste producers?	
IV.3. Are any of the R, K & M preservation measures described in this document intended to be carried out by waste management organisations?	
IV.4. Are any of the R, K & M preservation measures described in this document intended to be carried out by regulators?	
IV.5. Are any of the R, K & M preservation measures described in this document intended to be carried out by NGOs (non-governmental organisations)?	
IV.6. Are any of the R, K & M preservation measures described in this document intended to be carried out by local or regional governments?	
IV.7. Are any of the R, K & M preservation measures described in this document intended to be carried out by national government(s)?	
IV.8. Are any of the R, K & M preservation measures described in this document intended to be carried out by international organisations?	
IV.9. Is international cooperation discussed in this document as part of a strategy to preserve R, K & M?	
IV.10. Does the intended audience or recipient of the R, K & M discussed in this document include waste management experts?	
IV.11. Does the intended audience or recipient of the R, K & M discussed in this document include government or regulatory organizations?	
IV.12. Does the intended audience of recipient of the R, K & M discussed in this document include the general public?	
V. WHERE	
V.1. Does this document discuss local storage and management of R, K & M, e.g. at or near the repository site?	
V.2. Does this document discuss regional storage of R, K & M?	
V.3. Does this document discuss national storage of R, K & M?	
V.4. Are existing national archive organisations discussed in this document as part of a storage strategy for R, K & M?	
V.5. Does this document discuss R, K & M storage on a regional international basis (e.g. by organisations such as the EC)?	
V.6. Does this document discuss R, K & M storage on a generic international basis (e.g. by a UN	

agency)?	
VI. HOW	
VI.1. Are managerial/institutional/organisational methods of preserving R, K & M that rely on a continuous chain of transmission to the future discussed in this document?	
VI.2. Are direct methods of transferring R, K & M to future generations, e.g. markers, discussed in this document?	
VI.3. Are practical technical methods of storing and transferring information, e.g .permanent paper, electronic means, etc., discussed in this document?	
VI.4. Are material methods of transferring information, such as physical markers, discussed in this document?	
VI.5. Is the durability of materials or storage techniques for preserving information addressed in this document?	
VI.6. Are methods of evaluating costs of storing and maintaining R, K & M discussed in this document, and/or are actual cost evaluations described?	
VI.7. Are responsibilities for funding of R, K & M preservation measures discussed in this document?	
VI.8. Are methods of establishing funds for R, K & M preservation and transferring them to the future discussed in this document?	
VI.9. Is establishment and maintenance of heritage as a means of preserving R, K & M discussed in this document?	
VI.10. Are cognitive means (e.g. visual) to preserve and transmit R, K & M discussed in this document?	
VI.11. Are intellectual means (rational, explicit) to preserve and transmit R, K & M discussed in this document?	
VI.12. Are social means (institutional or heritage) to preserve and transmit R, K & M discussed in this document?	
VI.13. Are intuitive means (e.g. aversive symbolism, analogies) to transmit R, K & M discussed in this document?	
VI.14. Is self-marking (geophysical, superficial geomorphology i.e. landscape features) as a means of transmitting R, K & M discussed in this document?	
VI.15. Is monitoring discussed in this document as a primary mechanism for maintaining R, K & M?	
VI.16. Is monitoring discussed in this document as a secondary (supporting) mechanism for maintaining R, K & M?	
VI.17. Is accessibility of the stored R, K & M discussed in this document?	
VI.18. Are multiple (complementary, parallel) methods of preserving and transferring R, K & M described in this document?	
VII. OPEN-ENDED SUPPLEMENTARY QUESTION	
VII.1. Are there other aspects of interest for R, K & M in this document that were not covered, or not covered adequately, by the above questions? If so, please describe.	

Discussion Notes

It was mentioned that there seemed to be very few mentions of monitoring. RK&M preservation could guide monitoring – is this linked to the human environment or the living memory? R. Ferch replied that he had not noticed this, but he would make a note to look for it in future analysis.

It was asked if R. Ferch had a view on whether RK&M preservation could guide monitoring. R. Ferch replied that it could guide types of information we should be passing on – and the more information we can give, the better.

HOW TO PRESERVE RK&M – PART I

SESSION 4 - Mechanisms for RK&M preservation and recovery, in the short term

18. Knowledge retention strategies across generations

John Day, Sellafield Limited, United Kingdom. Eelco Kruizinga, Det Norske Veritas, Netherlands.

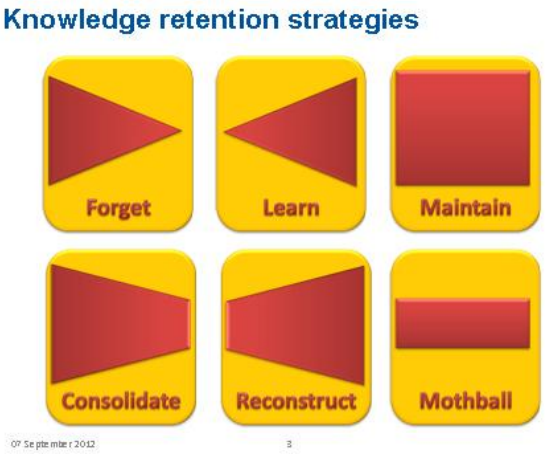
Introduction

Previously, we argued that the preservation of records is a necessary, but not a sufficient condition to enable intelligent future decision making and safe management of nuclear waste: knowledge is essential for the generations that follow us. Consequently in this paper, we address the follow-up questions: "What is it that future generations need to know and when?" and: "What would a plan for knowledge retention look like?" By applying the techniques for knowledge retention planning used in the 120 year Nuclear Decommissioning programme at Sellafield to a UK geological disposal reference case, we have demonstrated the applicability of the approach. We further develop definitions of six different knowledge retention strategies and apply these to example knowledge areas and close with a number of conclusions and recommendations.

Knowledge is needed to manage geological disposal

Although the creation and maintenance of records of nuclear waste is fundamental for public acceptance, it is of even more importance that a society maintains the capability and knowledge to manage the geological disposal system.

However knowledge could get lost and the challenge is to maintain a level of knowledge readiness, across a long timeline with both planned and unpredictable discontinuities in society and technology. We believe that current Knowledge Management practices provide some of the processes and tools to address this challenge. Experience demonstrates that knowledge can indeed be retained in a complete and ready state if an organised and systematic approach is employed. If we are able to extend or repeat the knowledge retention processes, then in theory at least we have a solution that is robust across generations.



The long term management of knowledge can be characterised by six different major retention strategies; ' 'Forget', Learn', 'Maintain', 'Consolidate', 'Reconstruct' and 'Mothball' which we define thus:

Forget: *Manage the knowledge base down to a point such that explicit and tacit knowledge is not available*

Learn: *Develop new knowledge such that it is complete and readily available at the point of action*

Maintain: *Manage knowledge such that knowledge is continuously complete and readily available at the point of action.*

Consolidate: *Bring together a) dispersed documented knowledge into a single, unified and accessible whole, discard unused or unwanted documentation, validate and organise the remaining documentation so that it is readily available, valid and complete b) design, fill and maintain a minimum reservoir of tacit knowledge*

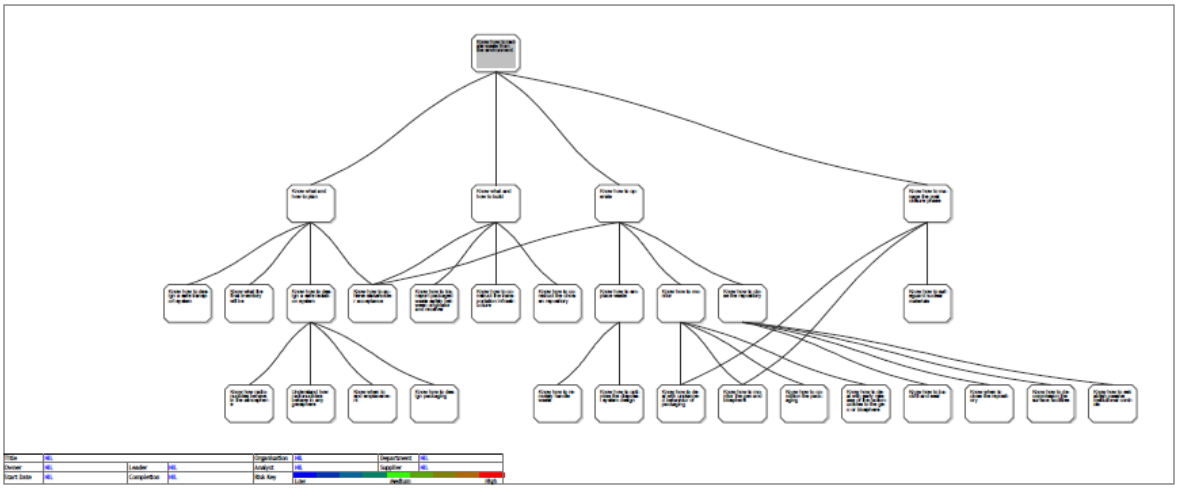
Reconstruct: *Build full knowledge readiness from mothballed knowledge and initiate knowledge maintenance*

Mothball: *Preserve over long periods the consolidated tacit and explicit knowledge for later reconstruction*

Examples exist of good practice for each of these strategies and each requires resources and planning appropriate to the nature and timescale of the knowledge in question.

The results of mapping the knowledge domains

As the implementation of knowledge retention strategies is a resource-intensive task, it is essential that this is preceded and guided by a comprehensive mapping identifying firstly what critical knowledge is required for the whole lifetime of the facility, and secondly when it is required.



Knowledge map for the UK reference case

We have mapped the essential knowledge domains for the UK geological disposal reference case. For completeness the knowledge map also identifies knowledge that enables future generations to manage the facility and its contents, purposefully and safely, to appreciate and respond to emerging risks and events associated with the store. Essential knowledge includes knowing what to do, knowing why this is the right thing to do, knowing how to take action and having the capacity to do so.

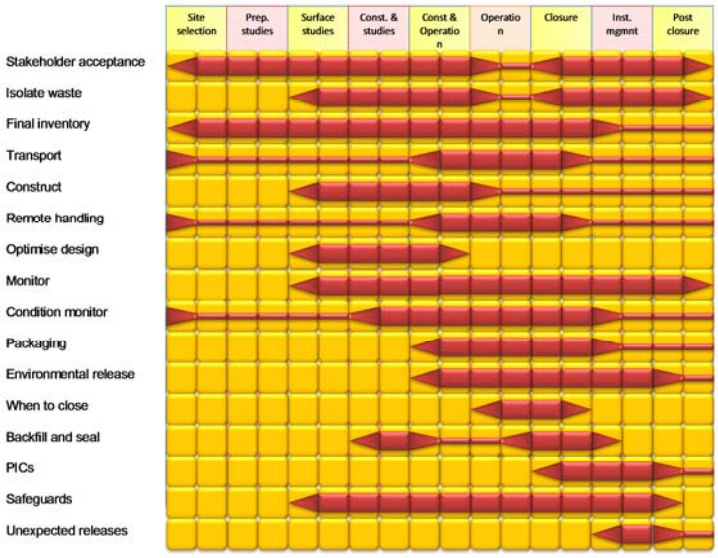
The knowledge map created contains the follow entries (in alphabetical order):

- Know how radionuclides behave in the atmosphere
- Know how to achieve stakeholder acceptance
- Know how to backfill and seal
- Know how to close the repository
- Know how to condition the packaging
- Know how to construct the chosen repository
- Know how to construct the transportation infrastructure
- Know how to deal with unplanned behaviour of packaging
- Know how to deal with early release of the radionuclides to the geo- or biosphere
- Know how to decommission the surface facilities
- Know how to design a safe isolation system
- Know how to design a safe system to isolate radionuclides in the chosen geological repository.
- Know how to design a safe system to transport packaged waste safely between originator and receiver
- Know how to design the packaging in order to transport and isolate the inventory from the environment within the geological context
- Know how to emplace waste
- Know how to establish passive institutional controls (PIC)
- Know how to waste from the environment so that it is not released back to the surface in sufficient quantities to cause harm to people and living things
- Know how to manage the post closure phase
- Know how to monitor the geo- and biosphere to identify release from the chosen repository
- Know how to operate
- Know how to operate the repository
- Know how to optimise the disposal system design
- Know how to remotely handle waste
- Know how to safeguard nuclear materials
- Know how to transport packaged waste safely between originator and receiver
- Know what to build and how to build it
- Know what the final inventory (waste type and volume) will be
- Know when to close the repository
- Know when to end emplacement
- Understand how radionuclides behave in any geosphere

From the knowledge map which identifies approximately 30 major knowledge areas, we have created a schematic knowledge retention timeline which identifies, for each knowledge area, when it needs to be available at various significant points in the store's lifecycle. Traditionally, Knowledge Managers concentrate on just two strategies: i.e. the just-in-time development of knowledge ('learn') and the continuous maintenance of knowledge ('maintain'). We believe that in the context of the RK&M programme, the four other strategies identified above are also required, including the managed de-investment in knowledge ('Forget') frequently associated with the introduction of new technologies that make knowledge of earlier technologies redundant and wasteful to maintain, and the long term preservation at a minimum level for later reconstruction ('Mothball').

Nine time periods were identified that require significant changes in strategies for knowledge retention. This is a necessary development of the five repository life phases model, as knowledge retention strategies show variation within these five phases. The nine periods are illustrated in the adjoining figure.

The periods used are: site selection, preparatory studies, surface studies, construction and studies, construction and operation, operation, closure, institutional management and post closure. Each period is made up of two major knowledge retention strategy blocks.



A portfolio of knowledge retention strategy timelines for the UK reference case

Example knowledge retention plan for a knowledge area

We have extracted from the portfolio of knowledge retention strategies a single knowledge area ('Remote handling') to illustrate that, over time, a variety of processes, tools and techniques will need to be deployed to retain knowledge over the short, medium and long term. This is also the case for all the other knowledge areas identified. It is noted that records do play their part in all strategies, as does literacy, but they are insufficient on their own without a concerted effort to retain knowledge.

The knowledge retention strategy timeline for 'Remote handling'

The knowledge retention strategy in this example has six distinct phases. Examples of the types of activities to be undertaken in each phase are described in the following table. Each of the building blocks of the knowledge retention strategy covers half of one of the nine time periods, illustrating the need for long-term strategising beyond the preservation of records.

	• Consolidate explicit knowledge – Gather and review and validate specifications, drawings, design rationale, operating experience, procedures, work flow, training materials etc • Capture implicit knowledge – Video, interviews, with designers, commissioners and operators • Preserve equipment – prevent destruction of working examples
	• Preserve explicit knowledge – Preserve documents • Preserve implicit knowledge – Preserve videos • Maintain tacit knowledge reservoir – R&D projects, Require regular inspection • Preserve equipment – keep examples of equipment working
	• Preserve explicit knowledge – Review the preserved explicit knowledge and draw lessons • Build tacit knowledge – Train new group of designers and operators using preserved knowledge and artefacts • Design and build equipment – Amalgamate original designs with new technologies
	• Maintain explicit knowledge – Capture, review and maintain currency of documented procedures, research etc. • Maintain SQEP – Recruit, train, SQEP workforce
	• As above

All of the actions listed above are based on recognised good practice in the nuclear industry and elsewhere and have been demonstrated to be effective over extended time periods.

Conclusions

- As argued in the previous contribution and the example knowledge retention plan in this paper, knowledge can survive without records, but records are of no value when the reader is disempowered by ignorance. Therefore, the focus of the RK&M Project should be on the preservation of knowledge and how records can assist in this regard, rather than vice versa.

- The knowledge mapping and long term knowledge retention planning successfully applied in the field of nuclear decommissioning can also be used to help future generations make informed decisions and take intelligent action with respect to geological disposal of nuclear waste.

- The exercise has revealed that each knowledge area to be retained has very different characteristics and a range of different knowledge retention strategies will need to be adopted in order to give the public confidence in the robustness of arrangements to ensure safety and the responsiveness of society to manage future scenarios

Recommendations

1. This project should consider all knowledge preservation requirements.
2. International cooperation during the mothballing phases should be pursued to make arrangements more robust.
3. Sources of commercial, intellectual, moral or regulatory impetus to preserve a knowledge base at sectoral, national or international level need to be explored further.
4. To build public confidence, the reliability of knowledge retention tools over extended periods should be researched further.

Discussion Notes

J. Day confirmed that the Knowledge Retention approach described was the basis of the strategy at Sellafield. In response to a question on costs, J. Day explained that the programme was part of integral costs, and so costs embedded in operations couldn't be separated out.

W. Ernst asked if there was a particular reason mothballing had been chosen rather than, for example, embalming. J. Day responded that 'embalming' would be a useful way of thinking about the preservation of tools, for example, as preserving an example of a tool is far more effective than preserving a description of it. However, tacit knowledge is also needed.

J. Day added that it was important to monitor knowledge to check that it wasn't being lost.

19. Knowledge Structuring

Disposal programme for high-level and/or long-lived waste (cat. B & C) in Belgium: A system of organizing knowledge based on safety and feasibility statements

J.P. Boyazis, C. Depaus, M. Capouet and M. Van Geet

Geological disposal in poorly indurated clay layers has become the *reference solution* of ONDRAF/NIRAS for the long-term management of category B&C wastes. The national and international peer review of the second Safety and Feasibility Interim Report (SAFIR 2) acknowledged in 2001 the maturity of the Belgian scientific programme and urged ONDRAF/NIRAS to move on to the implementation phase while pursuing RD&D necessary to reduce the remaining uncertainties.

In recent years, ONDRAF/NIRAS has worked out a new safety and feasibility strategy to frame and formalize the stepwise and iterative development of a geological disposal in a coherent and integrating manner, able to fulfil all identified management requirements. The strategy sets out in broad terms how it is envisaged that safe disposal will be achieved. It is mainly based on safety

principles established by IAEA which are, among others, passive safety, defence-in-depth, robustness, best available technology and optimization. The safety and feasibility strategy also includes the boundary conditions to be met and the requirements to be satisfied. Boundary conditions include, for example, the relevant international and national regulatory frameworks, institutional policy and conditions required by other stakeholders.

The *safety and feasibility statements* are the central tool of the new ONDRAF/NIRAS strategy. Most of these statements are derived from the safety concept and are organized in a hierarchical tree structure. The top-level statements define the a priori objectives pursued by the programme stage in agreement with the boundary conditions. Lower-level statements setting out more detailed requirements of these objectives are derived from these top-level statements in a top-down approach. The substantiation of the safety and feasibility statements, with the multiple lines of evidence and their associated uncertainties generated from the RD&D programme, is performed bottom-up. The assessment of the level of support given to the statements and the impact of the associated uncertainties to the higher-level statements provide an efficient and synoptic tool to steer the research and development activities and set the priorities between the issues to handle a given decision.

The multiple lines of converging arguments supporting every safety or feasibility statement show the robustness –in the sense of reliability- and the demonstrability of the assertions claimed.

Given the long time frames of development and implementation, boundary conditions might change and evolve to new requirements. Within the iterative process of the safety strategy, reviews of the statements are possible and sometimes necessary. E.g. during the public consultation of the ONDRAF/NIRAS Waste Plan for the long-term management of conditioned high-level and/or long-lived radioactive waste, there was a clear request on retrievability. This is now included as a condition for further development of geological disposal and thus is being translated within the safety and feasibility statements.

The introduction of safety and feasibility statements in the Belgian programme resulted in significant changes. In particular, reorganisation of the RD&D programme around the need to substantiate the statements has led to a more efficient and pertinent prioritisation of the issues. The statements provide the means for a permanent consistency check between requirements on the system and its components, expected to become more stringent as the programme progresses and the knowledge available to assess whether the requirements are met increases.

The whole system of safety and feasibility statements is now incorporated in a specific Knowledge Management tool, which includes document management, QA/QC flow charts, writing modules for minutes of meeting or scientific reports dashboards for e.g. follow-up of actions and decisions, data clearance tables with links to original references.

This approach based on the safety and feasibility statements is an essential structuring element of future safety and feasibility cases. The synoptic and structured view provided by the statements hierarchy of the knowledge increases understanding and transparency.

The new ONDRAF/NIRAS knowledge management system, combined with the hierarchized safety and feasibility statements approach:

- helps ensuring the tracing of the substantiation of the statements;
- contributes to increase consistency between all the aspects of the safety and feasibility case;
- helps to prioritize the research;
- is an ideal guiding tool for the completeness checks of the assessment basis;
- helps organizing the treatment of remaining uncertainties in the assessment cases;
- constitutes a base for the dialogue with the stakeholders on safety aspects and design (for example, the recent discussions on monitoring programme for deep disposal with the local partnerships STORA and MONA in the municipalities of Dessel and Mol).

It will be later used as a guiding tool for establishing the requirements of the technical specifications for the construction of the repository and its components.

SESSION 5 - MECHANISMS FOR RK&M PRESERVATION AND RECOVERY, IN THE MEDIUM TERM

21. The DOE Office of Legacy Management

Inviting People in as Opposed to Keeping Them Out: An Alternative Strategy for Knowledge and Memory Preservation

David S. Shafer, Ph.D.

U.S. Department of Energy, Office of Legacy Management

Remediation of sites contaminated with radioactive and hazardous waste and materials in the United States (U.S.) associated with the Cold War began in the late 1970s and early 1980s with the passage of legislation such as the Uranium Mill Tailings Radiation Control Act (UMTRCA) in 1978 and the Comprehensive Environmental Response, Compensation, and Liability Act in 1980. It accelerated and become a major part of the mission of the U.S. Department of Energy (DOE) with the creation of the Office of Environmental Management (EM) in 1989. However, as progress was made in remediating sites, it become clear that many sites would continue to have liabilities and pose potential risk after they were closed according to regulation. The U.S. National Academy of Sciences, identified "long-term stewardship" needs at "legacy sites" to include several that resonate with the objectives of Records, Knowledge, and Memory (RK&M) Project including 1) preventing inappropriate use of sites where risks remain or where wastes were disposed while also 2) facilitating ecological processes and appropriate uses; 3) maintaining and repairing engineered remediation structures and systems, and replacing them if they were failing; 4) archiving knowledge and data to "inform the future" about what occurred at a site and what risks remain; and 5) educating communities, decision makers, and other stakeholders as part of "renewing memory of a site's history, hazards, and burdens (National Research Council, 2003)."

To focus on these needs, the Office of Legacy Management (LM) in DOE was created in 2003 (http://www.lm.doe.gov). LM's mission includes 1) ensuring remediation systems and waste disposal sites remain protective of human health and the environmental through its Long-Term Surveillance and Maintenance (LTS&M) program; 2) preserving, protecting, and making accessible legacy records and information, and 3) managing legacy lands and assets, including putting them into beneficial reuse when possible (USDOE LM, 2008). Although at first glance, these may seem as separate and distinct objectives, with practice they are being used collaboratively to protect public health and the environment and preserve knowledge and memory of sites.

At its formation, LM inherited responsibility for 33 sites that were already closed, primarily UMTRCA sites. As of September 2012, LM is responsible for 90 sites in 28 states and the U.S. territory of Puerto Rico. It is anticipated that by 2019, the number of LM sites will grow to 120 as site remediation is completed by EM and as the U.S. Nuclear Regulatory Commission transfers additional sites remediated under UMTRCA. One measure of the importance of preserving knowledge of sites is that 34 LM sites are "records related and stakeholder support" sites because they were "clean-closed" or have negligible residual risks. However, the "condition" of these sites can change. For example, examination of new records and dialogue with local stakeholders is leading to a second remediation at the Chariot Site in Alaska even though the State of Alaska certified the site for "unrestricted use" after radiological contaminated soil was removed in 1993.

To give themselves a central point, LM opened a records management, storage, and information technology center in Morgantown, West Virginia in 2010. Records that were housed at various locations in the U.S. are being centralized there, although duplicate records needed for LTS&M of sites and for communication with stakeholders are kept at local LM offices and sites. How the records are used to preserve knowledge and memory of sites is taking a variety of forms. For example, at two sites where high purity uranium metal was created, LM manages interpretive centers (ICs) at which visitors can learn about Cold War history of the site, the risks that remain (on-site disposal cells exist at both), and the natural attributes of the sites today. Both sites, Fernald in

Ohio, and Weldon Spring in Missouri, are successful examples of beneficial reuse of legacy sites. At Fernald, a variety of wetland habitats are being preserved or created as part of managing the "Fernald Reserve" for wildlife, particularly waterfowl. At Weldon Spring, a natural prairie ecosystem is being recreated at the site, an ecotype rare in the region today. Hiking/walking trails have been constructed at both, including a trail at Weldon Spring that takes visitors to the top of the disposal cell. Rather than trying to restrict access, people are being invited to the sites, but in a controlled manner from a risk management perspective.

Beneficial reuse of some remote sites include several UMTRCA sites at which DOE has established no-cost grazing agreements and ones for growing hay. This reuse has an added benefit: the rancher or farmer who uses the land serves as a local set of "eyes and ears" for DOE. They notify DOE if natural events have occurred at sites such as storms that might have damaged, for example, landfill covers; or if people are using the sites in a way that could pose a health or safety risk. In addition, at several of these sites, fences which mark the site boundary (and on which there are signs warning people of radiological risks) are also the boundary of the grazing area. The rancher maintains the fences so his cattle do not get away. Other examples of beneficial use at UMTRCA sites include baseball fields and soccer pitches atop land with subsurface contamination, and solar energy voltaic systems.

At all the sites where reuse is occurring, there are administrative institutional controls (ICs) in place, usually enforced by local governments, which restrict certain uses (e.g., drilling a well in an area with contaminated groundwater). As part of LTS&M, DOE has always inspected the condition of physical controls such as signs and monuments. But the concept of LTS&M is now expanding to include evaluating the effectiveness of administrative ICs. For example, if new drinking water wells are prohibited in area, who is responsible for reviewing well permits? Do they understand the restrictions and why the restrictions were established? Why have administrative IC's failed at a few sites? While reuse of a site has its potential risks, it has the potential to be an effective IC in itself. If use is made of the land in a way that does not pose a health or environmental risk *and* is valued by the stakeholder community, it is less likely that an inappropriate use will be made of it. Engaging the stakeholder community in reuse decisions also provides an opportunity to preserve the knowledge and history of a site.
Preserving memory and knowledge is likely to be an increasingly important part of LM's mission.

Although some sites managed by LM were remediated more than 30 years ago, in most cases there remain people who have first-hand knowledge of them, such as former workers. However, this link to the past will soon be lost. In addition, beneficial reuse could be viewed as having unintended consequences. For example, if a site is returned to a near-original environmental condition or one with virtually no visual evidence of its past, it could be inadvertently developed in a way that could cause risks to humans because of the lack of visual clues as to its history. Strategically using records, such as before and after photos of a remediated site, at an information kiosk for someone to see before they start walking their dog or riding their bike at the legacy site could become as important a form of site remedy as any other by contributing to preservation of knowledge and memory.

Selected References

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Discussion Notes

C. Pescatore noted that the presentation was very pertinent to post-closure of a repository, and that this showed that oversight can continue.

The IAEA programme of Regulatory Supervision of Legacy Sites was raised as another example of this type of programme, but it was thought that there was no other organization solely dedicated to post-closure management.

P. Charton asked about the durability of funding for Legacy Management Department activities.

D. Shafer explained that Legacy Management was a small programme within the Department of Energy. There were around 65 direct employees and a few hundred contractors. Any government programme has to defend its budget, and as with every other programme they are trying to reduce costs and find a way to end programmes. For example, where monitoring is being used as a confidence-building tool, they will hopefully be able to wind them down.

W. Ernst questioned the name of the Legacy Management Department, saying that to his understanding 'Legacy' had cultural connotations.

D. Shafer replied that other terminology had been used, such as 'long term stewardship', but 'Legacy Management' had been settled on as in the US, it became the term for sites that had been granted regulatory closure but still had residual risks. He added that the department had responsibilities that went beyond RWM – for example, it also manages the pensions of previous workers.

L. Aparicio asked if reuse was a 'top down' approach or a response to stakeholder demand. D. Shafer replied that the demand for reuse largely came from a local level. All sites were located alongside rivers, and the positive response to the cleanup of these areas had generated a positive local response and a desire to reuse the sites.

D. Shafer said that the preference for reusing sites as nature reserves, for example, rather than building on them, is that as brownfield sites it is not safe to disturb the earth too far below the surface. Additionally, it was federal policy to make greater use federal land – for example, as a site for renewable energy sources.

C. Pescatore said that the lesson drawn from the Canadian experience is that if a community can use a site, it is viewed as safe.

22. Summary of Day One

The Safety Story: Regulation and Oversight

The Catalogue of RK&M regulatory guidance is developing. The project members will be asked to review and complete it. The current conclusions are that:

- There exists a broad sweep of guidance
- It is difficult to discern a common thread when looking to the medium and long term

The Survey of the IGSC carried out for the RK&M project shows that RK&M preservation is not seen as a safety requirement for post-closure performance. In safety cases, it tends to be accepted

implicitly that some form of RK&M preservation will exist and that it will avoid the danger arising from human actions at the site.

Oversight is a fundamental concept in the upcoming ICRP guidance on geological disposal. The concept was introduced initially by the R&R project.[16] Oversight requires the presence of man and covers activities such as regulatory supervision, societal involvement in the project, preservation of RK&M, and the verification of land use restrictions.

An initial survey on behalf of the RK&M project observes that more than half of the respondents indicate that there is an interest in local communities on the issue of preserving RK&M of the radioactive waste management facility for time periods beyond closure. When asked whether any actors in the national context acknowledge that local communities could play a role in monitoring and recording knowledge and memory preservation, the responses are positive in almost two thirds of the cases. So, early indications of stakeholder demand for monitoring show that it is more than probable that "oversight" will continue beyond closure, but what form will it take?

A review of the technical options for monitoring identifies three main drivers for post-closure monitoring of geological disposal facilities: technical, societal and safeguards. All of these will contribute to oversight and therefore to RK&M. More specifically, the following reasons have been given in support of post-operational monitoring: safeguards; understanding the evolution of the near-field; determining the post-closure evolution of the geosphere; evaluating the impacts of the repository on the surface; confirmation of performance assessment assumptions; aiding decision-making, e.g. for retrieving the waste or ending the institutional control phase; public acceptability and confidence; and legal requirements.

These drivers raise questions concerning the relationship between RK&M, monitoring and oversight. Concerns were raised that oversight could be seen as 'compensation' for a lack of intrinsic safety.

From a regulatory point of view, there are requests from the EC to detail post-closure memory preservation plans; the ICRP clearly suggests (to regulators) that oversight should be kept as long as possible (one does not abandon a functioning nuclear facility) and that records and memory keeping are part of oversight.

We are still in early stages of understanding what oversight may imply. Regulators have an important role to play in this regard.

There will be a MoDeRn conference in March 2013, focusing on the technological means of monitoring during the operational period. The NEA is looking more closely to the post closure period (facts and possibilities) and to the position of communities and society at large.

Monitoring should be linked to other oversight activities. Note that there are already conventions that require radiological monitoring of the environment. These activities can be taken advantage of for providing information on the impact of the repository. One may not need to create new systems with which to monitor the repository – existing mechanisms should be identified and built upon.

Safeguards are a form of oversight, but the way they will be exercised is classified and nation-specific. Of interest is the fact that there would be yearly reports on safeguards requirements fulfilment, which is another form of enhancing memory preservation.

It is clear that oversight and its provisions are forms of extra assurance of safety. To what extent should these aspects of the safety story should be mentioned in the safety case? Or should a safety story be created of which the safety case is a part?

Whatever is done, it should be a proportionate response, recognising the the comparatively low risk posed by a repository.

It is not just institutions that can change over the timescales under discussion. Concepts such as monitoring and archives are societally determined phenomena, and may therefore evolve and be

superseded. The work of Cecile Massart, exploring our understanding of how to empower future generations, therefore becomes fundamentally important to the success of any preservation

[16] The OECD NEA Reversibility and Retrievability Project - http://www.oecd-nea.org/rwm/rr/.

programme: the regeneration of artistic elements on the site could provide a mechanism for continuous oversight.

Project Update

Within the project, the analysis of the RK&M bibliography is progressing. The early indication is a number of areas that have received relatively less attention. Namely, the question of establishing costs and funding for activities that may be required for ongoing preservation of RK&M; the role of NGOs in RK&M; the role of monitoring in both creation and preservation of RK&M; security and safeguards as motivations for preserving RK&M; questions about actions that might be taken in the long term to preserve RK&M and/or to mitigate loss of RK&M; and the role RK&M preservation might play in ensuring the existence of future expert knowledge needed to help preserve and interpret factual data and metadata in the longer term.

Conceptualising RK&M Loss and Recovery (Short And Medium Term)

When we deal with loss of records:

- The major factors are human factors (epistemic loss), especially concerning insufficient use or misuse of records.
- In respect of loss and misuse of records, regulators are the weak link. The regulators are subject to several vulnerabilities. Economic factors are next in line in importance, while technical factors do not emerge as an important concern in the short and medium term.

A complementary notion to "preservation" is "oblivion", or "culling". That is, a strategy of erasing/culling part of the information ('dedicated forgetting'), which is a good strategy at a certain point in time to help preserve that which will be necessary later. Culling may be seen as part of knowledge consolidation. Indeed, records and skills can be recovered if a mothballing strategy is prepared for and applied.

The safety case may serve as a powerful aid to this aim, as it could offer structure with regard to "what is known and is needed to be known", based on regulatory and societal requirements. Some possibilities are:

- It could be an essential structuring element of future safety and feasibility cases
- It could be a tool for;
    - Organising the traceability of the substantiation of the statements
    - The completeness checks of the assessment basis
    - To provide and evaluate support to the RD&D in an iteration and from a programme step to the next
    - In the treatment of the uncertainties to develop the scenarios and the assessment cases
- It is a basis for the dialogue with the stakeholders on safety aspects and design (e.g. in the recent discussions on the monitoring programme with the Belgian local partnerships STORA and MONA)
- Later, it could be used as a guiding tool for establishing the requirements in the technical specifications for the construction of the repository and its components

Knowledge can evolve from having been broadly spread to be carried by only a few hands and can also jump between different social and cultural categories. In Sweden, for instance, the most prominent carriers of the knowledge of how to manage and ride horses are no longer either land-

owning farmers, or nobility, but schoolgirls and their instructors. Also, knowledge can slowly transform so that original practitioners may not be able to recognize the practitioners or their

followers of today. What would Marx make of today's Marxists? What would Jesus and other prophets make of their religion and its practices?

The presentation from the Media-Archeology point of view argued that, in terms of knowledge recovery, it is important to have a continuum of cultural sense in order to understand "the message".

It was observed that the endless possibilities for change over very long time scales means the communicating to the future cannot depend on any cultural continuum. A possible model for thinking about the transfer of information into the far future is 'communication with extraterrestrials' – that is, with beings with whom we have no cultural connection. It may be that there needs to be a 'signal', or a mathematical code, that transmits the RK&M of the repository in a manner entirely removed from dependency on cultural understanding.

In every act of cultural transmission there is a symbolic component and a material component. Could radioactive decay provide both, i.e. both the signal and the information?

We should accept that there will be change and decay in how information is collected and transferred. This will create 'noise' – unintentional signals. However, the 'noise' can still be interesting to someone who is trying to understand the "signal".

The discussion on 'how to make things easier for historians of the future' observed that we may only want to help future generations "make sense" of what happened, rather than dictate to them what to do.

We will favor this quest for sense-making if we:

- Create cross references across many kinds and locations of source
- Create additional curiosity by suggesting that this is an exciting mystery or an enigma
- Try to provide info in an unusually full context (the records would comprise societal debates, scientists debates, videos, commemorative medallions, stamps, etc.)
- Make the record or memory media, e.g., the surface facility or markers, into spectacular artefacts.

It should be remembered that there is no more durable mark than a posthole, and signs will remain from repository construction.

These discussions bring up a tension: from a record management point of view, information becomes more accessible and easier to understand if it is 'culled', so that only relevant records are maintained. However, in order to allow future generations to make sense of the repository, having an 'unusually full context' is desirable.

This contradiction could be resolved through innovative knowledge management. A Knowledge Retention Strategy in the UK has developed the notion of mothballing, and how to conceptualise the preservation or discard of records and knowledge over a hundred year period by mapping knowledge and defines when it will be needed and how it should be managed – that is, if it should be 'consolidated', 'forgotten', 'mothballed', and so on. The reliability of these methods over longer timescales needs to be researched.

In Belgium, ONDRAF/NIRAS uses safety and feasibility statements, such as a structuring tool for the safety case. These act as a consistency check between system requirements and components, serve as guiding tool for the requirements of technical specifications for construction of the repository and its components. This increases the consistency between the safety and feasibility cases, helps to prioritise research and constitutes a basis for dialogue with stakeholders on safety aspects and design. They may be used for identifying RK&M needs, at least at technical level and through full licensing of the facility.

Records and Knowledge can provide both clarity and context; they should not be kept indiscriminately, but choosing between them may be the work of managers more than regulators.

Mechanisms for RK&M Preservation and Recovery in the Medium Term – Part I

The DoE Office of Legacy Management experience is evidence that management of past sites is being carried out in the nuclear field. Forms of continued oversight are therefore possible, and we seem to be undeterred by the fact that some sites will require oversight in perpetuity.

Oversight may be carried out by others than the original regulator (of transfer of responsibilities from the actual licensing body to a new oversight body). The new oversight body will be happy to have reasonably complete records; it should be remembered that what is considered complete may change, for example if regulatory requirements change.

The DOE Legacy Management presentation said that, "Having many sites across the USA may force us to have common markings". This could be a good example of cross-referencing information.

Additionally, the Office of Legacy Management has been using Site Reuse as a strategy for RK&M Preservation. This changes the focus of the site from what cannot be done to what can be done, thereby investing it with value for the local community.

Re-using a site enhances the concept that the site is sufficiently safe; it's a way to create memory and a sense of ownership in the community.

Involving stakeholders in monitoring sites is good practice. "In some cases we are conducting monitoring as a confidence building activity, eventually we think they will be reduced and closed down".

It is important, however, not to become complacent, and to ensure that an Agency exists for evaluating the administrative Institutional Controls. One should "Envision site reuse BEFORE sites are transferred". Finally, the regulatory concept of Risk-based Closure does not close debates about risk in the rest of society and it is a deterrent to transferring site responsibilities.

DAY 2

HOW TO PRESERVE RK&M – PART I (CONTINUED)

SESSION 5 (continued) - Mechanisms for RK&M preservation and recovery, in the medium term

23. Supranational Mechanisms to support Records, Knowledge and Memory Preservation over the medium term

Thierry SCHNEIDER, Cynthia REAUD, *CEPN & NEA Consultant*

Objective

The aim of this preliminary analysis, performed with the support of NEA, is to investigate the organisation of existing supranational mechanisms and their multi-level governance on the basis of available documents in order to identify their possible contribution for records, knowledge and memory preservation in the medium term (post-closure) for radioactive waste management. For this purpose, particular attention is devoted to pointing out the strengths and weaknesses of the supranational mechanisms related to their contributions to ensuring that future generations can base their decision on relevant and pertinent data and to promoting awareness of past activities.

Proposed analytical grid

For analysing the supranational mechanisms to maintain and develop oversight[17], as defined by ICRP in its forthcoming publication, and to keep memory in the medium term, the following analytical grid was adopted:

1. Organisation of the supranational mechanism:
    a. Type of mechanism and involved parties
    b. Adoption of common goal and ethical charter
    c. Financial mechanism and its sustainability
    d. Multi-level responsibility and decision process, its dynamics and assessment of its quality
2. Contribution of the supranational mechanism to:
    a. Development and mobilisation of expertise
    b. Local sustainable development
    c. Organisation of oversight and memory preservation

[17] In its forthcoming publication on geological disposal, the International Commission on Radiological Protection, oversight is defined as:

> "*Oversight is a general term for "watchful care" and refers to society "keeping an eye" on the technical system and the actual implementation of plans and decisions. It includes regulatory supervision and control, preservation of societal records and societal memory of the presence of the facility*."

Analysis of Supranational Mechanisms

Three groups of supranational mechanisms have been selected for this analysis:

- UNESCO World Heritage Convention

- UNECE (United Nations Economic Commission for Europe):
  - Convention on Environmental Impact Assessment in a Transboundary Context (Espoo Convention)
  - Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters (Aarhus Convention)

- Mechanisms linked with IAEA:
  - Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management
  - Treaty on the Non-Proliferation of Nuclear Weapons (NPT)
  - Convention on the Physical Protection of Nuclear Material
  - International Nuclear Information System (INIS)

Preliminary results of the analysis of supranational mechanisms

1) Organisation of the supranational mechanism:
   a) Type of mechanism and involved parties

   The different mechanisms are generally associated with international organisations such as United Nations or linked to European Commissions. These organisations provide them with the necessary technical and administrative support as well as platform of dialogue in order to set up the objectives and conditions and means for the elaboration of the supranational mechanism.

   The voluntary involvement of Member States to join the mechanism for a common goal and their declaration of adhesion to the objective constitute key components creating a real dynamic for the different conventions. Generally, the mechanisms are flexible and evolve progressively according the expectations of their members and the evolution of society. It is also interesting to mention the role the advisory bodies and possible observers (NGOs, local organisations…), who contribute to the efficiency of the mechanisms and their adaptability over the medium and long-term.

   Nevertheless, the capacity of action of these mechanisms is generally limited in cases of conflict insofar as they largely depend on the willingness of the partners to apply them and are not mandatory.

   b) Adoption of common goal and ethical charter

   Most of the mechanisms are based on the recognition of the individual and societal rights for protection issues and promote the duty of each member of the mechanism. This first step generally leads to the adoption of a common action plan. It is interesting to mention that the World Convention Heritage is structured around the concept of ***outstanding universal values***.

   The mechanisms provide a platform for establishing an "evolving" convention, relying on the voluntary involvement of member states and allowing them to address transboundary and transgenerational issues. Nevertheless, the prime objective of the supranational organisations, which drive the supranational mechanisms, is generally economic development, while the supranational mechanisms put emphasis on the need to also take into account societal and

environmental issues. This leads to some difficulties in the implementation of the mechanisms, as observed in some local situations, for example in the case of the World Heritage Convention.

c) Financial mechanism and its sustainability

The link with more general frameworks, such as UNESCO or IAEA, allows the mobilization of regular funds for the supranational mechanisms. But of course, the effectiveness of the financial support dedicated to the action plan adopted by supranational mechanisms depends on the willingness or the capacity of member states to provide specific funds over the medium and long-term.

Beyond the funds centralised by the supranational mechanisms at the international level, it is important to mention that the efficiency also relies on the capacity of the different stakeholders (local/national/international) to mobilise dedicated resources for their involvement in the decision-making process.

d) Multi-level responsibility and decision process, its dynamics and assessment of its quality

According to the aim of the supranational mechanisms, multi-level responsibility is at the core of their organisation. On this basis, the implementation of their multilevel responsibility and decision process depends on the willingness of the partners to reach compromise. This is of particular importance in cases of conflict or economic and social crisis.

The mechanisms provide different tools and frameworks to cope with information, participation and justice of the different stakeholders. This is generally at the core of the discussions among the members for implementing the conventions.

In this perspective, the key role of a supranational mechanism is to increase Member States' awareness on the issues at stake in the conventions and to sustain the common goal identified as well as to detect problems and, if necessary, to provide assistance, notably in cases of conflict or economic, social or environmental crisis, for instance associated with the occurrence of a natural disaster.

2) Contribution of the supranational mechanism to:
   a) Development and mobilisation of expertise

Associated with most of the supranational mechanisms, the establishment of advisory bodies, composed of networks of international experts, contributes significantly to the development of expertise and its sustainability. Furthermore, with the adoption of clear rules and ethical charter for the mobilisation of expertise, the mechanisms generally provide efficient framework at the different levels: local, national and international.

The involvement of local experts and the framework for mobilising pluralistic expertise are also crucial in the supranational mechanisms. Several mechanisms have also set up dedicated programmes to contribute to the capacity building of the different stakeholders, with specific focus on the development of local expertise. In this perspective, the development of guidelines facilitates the dissemination of information and the content of the convention to local expertise. This is particularly developed in the World Heritage Convention and in the INIS system through the support of local training centres.

b) Local sustainable development

The long-term sustainability of the actions promoted through the supranational mechanisms constitutes a real challenge, but this issue is generally not addressed as such in the supranational mechanisms analysed in this review.

The exception is the World Heritage Convention for which the preservation and the sustainability of the sites are crucial. Although this is relatively well managed in the framework of this Convention on a case-by-case basis, it is necessary to acknowledge that there are strong pressures on different natural sites associated with economic and social development issues (e.g. in the case of conflict with oil exploration on the site).

c) Organisation of oversight and memory preservation

This issue has not been explored in detail until now, but it is interesting to mention the existence of development of a database system in supranational structures grouping different sources of information and aiming at disseminating the information through national centres.

Furthermore, the supranational mechanisms provide dialogue platforms allowing the analysis and interpretation of collected information as well as discussion of the modalities of preservation of these data for medium and long-term.

Finally, it has to be noted that most of the mechanisms encourage the development of an "active memory" and its registration in the various records kept by the different stakeholders.

Preliminary conclusions and further investigations

This analysis shows that the supranational mechanisms can contribute significantly to the preservation of RK&M. In this context, it could be envisaged for RK&M issues in RWM to rely on such existing mechanisms. For this purpose, there is a need to identify the necessary adaptation of the existing mechanisms to cope with RK&M issues in RWM and to explore the conditions of implementation of a supranational mechanism in this domain (notably concerning partnership, funding, and development and mobilisation of expertise…).

To further investigate this issue, there is a need to complete the preliminary analysis based on the feedback on practical implementation of the mechanisms and to explore additional mechanisms, such as the new EC Directive on RWM, the INSPIRE EC Directive on Infrastructure for Spatial Information in the European Community, the Register of the Memory of the World and other supranational mechanisms related to environmental issues (OSPAR, UNEP, …). Specific attention will be dedicated to the process of preservation of archives and the development of sustainable knowledge as well as the organisation of emergency plan in cases of conflict or crisis.

On this basis, we plan to perform a cross-analysis of these different supranational mechanisms with regard to the different criteria adopted in the analysis grid and to further analyse the sustainability of the mechanisms and their ability to involve local stakeholders.

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24. The Role of Rituals

Jean Noël Dumont, ANDRA

Background

The combination of active features and passive markers is thought to be a favorable way to increase the efficiency of memory preservation efforts related to the existence of a radioactive waste repository. This is expressed by the dual track approach promoted by the RK&M project. An idea which emerged from artists suggestions in the framework of the memory program launched by Andra is that some rituals could be looked for, in order to foster memory in the medium term.

The lessons from the past

Looking back in the past, we may identify numerous rituals that have crossed centuries, for example:

- fairs, markets, taking place every year, or several times a year, sometimes since the Middle Age (Cf. Champagne fairs, since 12th century)
- religious ceremonies, taking place every year, at several dates, since one to a few thousands of years: Aïd el kebir, Eastern, Christmas, Yom Kippour…
- sportive and leisure events: Olympic games, world cups, cinema festivals (Cannes, Berlin, Venize…), music festivals (Bayreuth, Montreux…).

- awards ceremonies : oscars, Nobel Prize…
- national governance events: elections, crowning…

etc.

Looking at these rituals, characteristics which are favorable for durability may be identified.

- The ritual is always related to shared durable values and/or basic needs: trade, entertainment, science, justice, art, spirituality …
- The ritual is always supported by a large group of people: village, players, scientific community, nation, church…The minimum size of the group is probably a few thousand people.
- The ritual is often supported by a story which may be transmitted from generation to generation (« myth »)
- The ritual is often located in a specific place, and supported by an object (building, landscape, statue, painting…).

It could be expected that economic viability is necessary for the durability of a ritual, but this seems to be resolved by the two major characteristics presented above: if the ritual links with a shared value and interests a large group of people, funding comes with it.

Can we develop new rituals for the medium term?

If we want to develop rituals related to RK&M preservation, it therefore seems necessary to look for positive values, which will make the ritual worth reproducing. As the ritual must be linked to the existence of the repository, the search may start with pre-existing rituals, possibly at the embryonic stage, within the RWM activity. In this sense, the updating and relevancy assessment of archives, which may have a historical value, can be considered. Periodical environmental assessment reports, as they contain a scientific value, may also be considered as a possible basis for future rituals. Over the recent years, every year, an artist has been appointed by Andra to produce a work related to memory preservation. This could be continued.

Similarly, a prize award might also be established, in a field related to RWM disposal. This would encourage, for example, scientific and technological research in remote monitoring, in radiation effects, in heritage preservation…

Another idea may come from the Long-term Environment Observatory (OPE-Observatoire pérenne de l'environnement), that was established by Andra in 2007 to precisely describe the environment found at the future site of the industrial center for geological disposal (Cigeo). As part of its project to construct a deep geological repository for radioactive waste, ANDRA must put in place a coherent set of means for environmental observation, experimentation and preservation. The OPE must therefore:

- establish an environmental baseline of the disposal site over 10 years, physical and chemical as well as biological and radiological;
- preserve the memory of this environment;
- prepare an environmental monitoring plan for the future disposal facility;
- help understand interaction between the different habitats and monitor the changes that take place in order to accurately gauge the impact of repository;
- define the origins of any observed disruption.

For this, the OPE has implemented a multidisciplinary observation program (water, air, flora, fauna and humans) over a period of at least 100 years. The program could be extended after the closure of

the repository. For example, the environment samples collected might be considered as possessing a heritage value to be preserved. Scientific observations related to climate change might also be continued.

Therefore, ideas exist to develop rituals for the medium term. Of course, there is no guarantee that these rituals will last for centuries, as we can never decide for future generations. However, the more a positive value given to a ritual, the more chance it will have to last.

The operational phase of the RWM repositories offers an opportunity to test various ideas and to develop the positive value for the medium term of the most promising rituals. This would benefit from international cooperation, through the exchange of ideas, benchmarking and networking.

Discussion Notes

W. Ernst asked if J-N. Dumont was aware of the suggestion by Thomas Sebeok that there should be an 'Atomic Priesthood', who would create a myth of of the story of radioactive waste disposal, to be passed on within a closed group. The idea is that secrecy is one of the key factors of success for memory preservation. J-N Dumont confirmed he was aware of the work but did not think it had any serious possibilities, and was fundamentally different to the work presented here as it centered on a closed group.

25. Plenary Discussion

T. Kaiserfeld remarked that the crucial element of a ritual was its durability. Some rituals are only meaningful to a few, and the challenge of rituals like this is to fill it with meaning.

H. Ceulemans suggested that as long as the 'nuclear age' lasts, the memory would be preserved – so the question becomes, what do we anticipate as being the 'nuclear age'? Beyond the use of nuclear power, the memory will have no substantive basis in knowledge which is in daily use.

T. Schneider remarked that the problem is exacerbated by looking at it solely as a nuclear issue – if it is put into the broader international stage, nuclear power becomes an element of the process of memory.

M. Kučerka asked if T. Schneider considered the role of archiving regulation in his study. T. Schneider replied that the current focus was the mechanics of the conventions, but it would be an element for further study, and he would be looking at the possibility of new mechanisms.

SESSION 6 - Mechanisms for RK&M preservation and recovery, in the long term

27. Short Report: Tsunami Stones

Memory Saves Lives: Intergenerational Warnings Effectiveness

Abe Van Luik, US Department of Energy WIPP Programme

The 2011Tōhoku earthquake and tsunami was a world-class natural disaster. According to Wikipedia contributors, it was "the most powerful known earthquake ever to have hit Japan, and one of the five most powerful earthquakes in the world since modern record-keeping began in 1900." The toll in terms of human lives lost and property destruction was unimaginable. Even the word 'horrible' is inadequate to describe the suffering and misery that resulted.

Nations with nuclear power programs are engaged in, or at least planning to become engaged in, arranging to eventually dispose of their higher-level radioactive waste materials in deep geologic repositories. Geologic repositories are passive safety systems, and if undisturbed isolate these dangerous materials form the biosphere for extremely long times. The key words, however, are "if undisturbed." To assure that future generations do not inadvertently drill into repositories, national programs, and the international community [the Records, Knowledge & Memory (RK&M) preservation project of the Nuclear Energy Agency, for example), are proposing to place markers

and/or monuments on closed repository sites that say “do not drill here, and this is why” in various sophisticated ways.

Such markers or monuments are attempts at providing passive institutional controls. Their potential messages are under active discussion, and are not the topic of this paper. This paper addresses the question of how effective the messages from a past generation are to a present generation.

Insight into the potential effectiveness of future-generation warnings may be gained by looking at the effectiveness of monuments erected by past generations in Japan to warn their future generations of the dangers of tsunamis. It is not a pleasant thing to look into the details of what happened in Japan. However, there were several places where the stone warnings from the past were taken very seriously. There were other places, perhaps the majority of places, where trust in modern technology led to the ignoring of these warnings.

The illustrative cases used in this paper have been drawn from the Internet. Attempts were made to verify the content of one online source used. The internet article author was contacted. Separately, his two major sources were also contacted. No responses came from any of them. However, the content cited in this paper was independently reviewed, verified to be unbiased, and confirmed to be credible[18].

Two general responses seem to have occurred in todays’ Japan to the stone warnings created by their ancestors. The first response describes a community that actively kept alive the memory of a disaster from a thousand years ago[19]:

> Collective memory, as much as science and engineering, may save your life. . . .
>
> *A millennium ago, the residents of Murohama, knowing they were going to be inundated, had sought safety on the village's closest hill. But they had entered into a deadly trap. A second wave, which had reached the interior of the island through an inlet, was speeding over the rice paddies from the opposite direction. The waves collided at the hill and killed those who had taken refuge there. To signify their grief and to advise future generations, the survivors erected a shrine. . . .*
>
> *Some 50 generations later, on March 11, 2011, the Murohama tsunami warning tower — which was supposed to sound an alarm — was silent, toppled by the temblor. Still, without the benefit of an official warning system supported by modern science, the locals relied on the lesson that had been transmitted generation to generation for 1,000 years. "We all know the story about the two tsunami waves that collided at the shrine," I was told.*
>
> *Instead of taking refuge on the closest hill, the one with the shrine, they took the time to get to high ground farther away. From the safety of their vantage point they saw two tsunami waves colliding at the hill with the shrine, as they did long ago. Tragically, not everyone made the right choice; I was told of at least one person who died.*

Several other towns survived because of the warnings being kept actively in the population’s memories. Sadly, according to a New York Times article by its Tokyo Bureau Chief[20]:

> *Local scholars said only a handful of villages like Aneyoshi heeded these old warnings by keeping their houses safely on high ground. More commonly, the stones and other warnings were disregarded . . .*

[18] Reviewers were Hiroyuki Umeki, Director General of the Geological Isolation Research and Development Directorate, Japan Atomic Energy Agency, and Hideki Sakuma of that same agency.

[19] Source, interview with José Holguín-Veras, Los Angeles Times, March 11, 2012, http://articles.latimes.com/2012/mar/11/opinion/la-oe-holguin-veras-tsunami-20120311.

[20] Source: article by Martin Fackler, April 20, 2011, New York Times, http://www.nytimes.com/2011/04/21/world/asia/21stones.html?pagewanted=all.

> *Japan had neglected to teach its tsunami lore in schools. He said the nation had put too much store instead in new tsunami walls and other modern concrete barriers, which the waves easily overwhelmed last month.*

Implications from the Japanese experience for warning markers and monuments to be placed on closed repositories will be discussed in this paper.

Discussion Notes

C. Holtorf said that he shared L. Van Luik's opinion that tsunami markers would not be a good strategy to follow in the case of radioactive waste. He also said he shared the view that a more advanced technological society may be able to cope with the consequences of intrusion, but was cautious about the idea that the threats from repository are small. S. Hotzel also warned to be careful with comparing types of disasters, and that the possibility still remains that a geological disposal may cause many deaths over the long term. A. Van Luik noted that a colleague had also been concerned that his presentation discounted the risks of a repository.

W. Ernst asked if there was not a fundamental difference between marking an event like a tsunami and a non-event of ten thousand years of decay. A. Van Luik agreed that this was an important distinction.

28. "The Long Now Foundation: Fostering responsibility in the framework of the next 10,000 years."

Alexander Rose, Executive director and project manager of the 10,000 Year Clock

The Long Now Foundation was established in 01996* to develop the 10,000 Year Clock and Library projects, as well as to become the seed of a very long-term cultural institution. The Long Now Foundation hopes to provide a counterpoint to today's accelerating culture and help make long-term thinking more common. We hope to creatively foster responsibility in the framework of the next 10,000 years.

The 10,000 Year Clock project was conceived by computer scientist Danny Hillis as an icon to long-term thinking. After spending most of his life making computers increasingly faster, he became aware that there was much to be gained in projects that might move slower. Many social and environmental issues such as climate change, education, and poverty that require long-term thought and care, by their nature cannot be solved in a single election cycle, or sometimes even in a generation. The thought was to provide an example of a civilization scale project to provide a balance, a corrective, or at least a model of what could be done. An architectural scale 10,000 Year Clock, ticking away slowly in a remote mountain, reminding civilization that the things that matter often operate on a very slow scale. The Long Now Foundation has already built several clock prototypes, and we are now creating a full scale version underground in west Texas. Excavations have already been made over 150 meters deep to house the Clock, and the mechanical parts are now being built for installation in the coming years.

The 10,000 Year Library project was originally thought of almost as an answer to the question posed by the Clock. Now that we are thinking about the next 10,000 years, what do we do? The Long Now Foundation has started several projects that hope to at begin to answer this. One of the first of these library style projects is The Rosetta Disk. A nickel disk micro-etched with information in thousands of languages. The rationale is that over millennia, the platform that is most dangerous to lose is a language itself. The loss of a language, as the original Rosetta Stone taught us, is often the loss of a long and valuable history and world view. Over the last 12 years we have brought together the broadest collection of languages on the planet and released several editions of our Rosetta Disk. An early prototype of the disk was flown on the European Space Agency's Rosetta Mission to a comet.

Other library projects include a speaking series on long-term thinking we have run monthly since 02003, and a type of responsibility roster called Long Bets. Long Bets is a place where predictions may be logged and countered as bets, with real money, on any subject of long-term social or

scientific consequence. The goal is to build a large enough corpora of well argued predictions about the future, that we might review them with hindsight, and start to find better ways of thinking about the future itself. All the winnings of each bet go to the charity of the winner's choice. We presently have bets that could range into the billions of years and hold over a $1,000,000 in stakes.

Creating a mechanical clock or micro-etched disks is not the actual goal of The Long Now Foundation however. It is our hope that by generating these ambitious projects, that we inspire people to think long-term about issues that matter to them. Hopefully we might create new stories and myths about long-term thinking itself. Of all the ways civilization has successfully moved ideas through generations, storytelling is by far the most successful. The Epic of Gilgamesh, various books of the Bible, Beowulf and others have lasted as stories passed down from one person to another. Stories require no technology or invention other than language and curiosity. So far we have had some success in creating new stories. The New York Times best selling fiction author, Neal Stephenson included 10,000 year clocks in his novel Anathem (some as markers for nuclear waste sites). It is our hope to continue to inspire the thinking, and the next stories, that last the next 10,000 years.

* *The Long Now Foundation uses five-digit dates, the extra zero is to solve the deca-millennium bug which will come into effect in about 8,000 years.*

The Long Now Foundation - www.longnow.org

The Rosetta Project - www.rosettaproject.org

Long Bets - www.longbets.org

Seminars About Long-term Thinking - www.longnow.org/seminars/

Discussion Notes

In response to a question on the timescales for the delivery of the project, A. Rose said there was no definitive deadline, as it was more important to do the project well than quickly, but he expected it would be finished within the decade.

M. Jensen suggested that the long working period would also create performance information -for example, the leak shown at the Svalbard Seed Vault which had been shown. M. Jensen asked if the Long Now Foundation had considered how to follow up on the operation of the clock once it had been built.

A. Rose responded that the intention was for the Long Now Foundation to exist alongside the clock, to carry on promoting 'long term thinking'.

C. Holtorf noted that the ambitions and method of the project were very similar to those of the RK&M project. However, he said that the ambition – a ten thousand year clock – would definitely fail. Such projects – for example, the Svalbard Seed Vault – were a product of a late twentieth century school of thought, which would become irrelevant.

A. Rose said that this was a good point, but the most valuable thing both of these projects have in common was not their success or failure – which was really irrelevant. The problem of RK&M preservation was really a non-problem, as the risk was so low, so the real aim was to give people confidence about the lack of risk. Engagement with the public is the project – not the success or failure in ten thousand years' time.

C. Mays suggested that we were dealing with the 'current present' rather than the 'long now'. A. Rose said that he understood the 'long now' as a string of 'presents'. The clock doesn't stop in ten

thousand years – it creates engagement in each present with the idea of the far future and the span of civilizations.

29. The Nanoform : Sapphire Disk System of Records Preservation used by ANDRA

Alain Rey - ARNANO

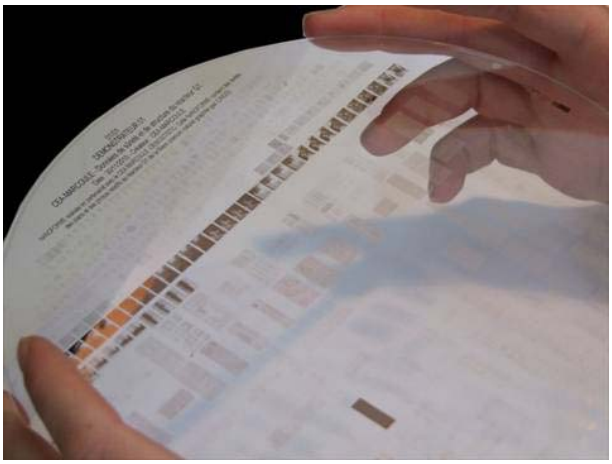
Introduction

Our 21st Century information society has to face a fundamental dilemma. In the course of the development of our society, the volume of generated information has increased exponentially, whereas conversely, the lifetime of storage media has decreased exponentially (1). Currently, the preservation of data is mainly obtained on paper (sometimes called permanent paper), on microforms or on numerical media, with permanent restoration. However, there is now considerable concern regarding the potentially catastrophic risks of information loss (2-5). In general, it is now recognised that the different techniques of information storage are not long term secured against the risks of exceptional events.

The Nanoform solution of Arnano represents a dramatic breakthrough in this domain, offering the possibility of media with lifetimes longer than several thousand years and resistant to fire, flooding, rats, etc. This innovation introduces a new era for the conservation of the memory of our human heritage and history as well as national or company's archives, and even family records. From this perspective, Arnano can be compared with the Arctic "doomsday vault" initiative, inaugurated in February 2008 by European Commission President Jose Manuel Barroso and Nobel Peace Prize winning environmentalist Wangari Matai, filled with samples of the world's most important information, and aimed at providing mankind with a Noah's Ark of data in the event of a global catastrophe (6).

The nanoform innovation

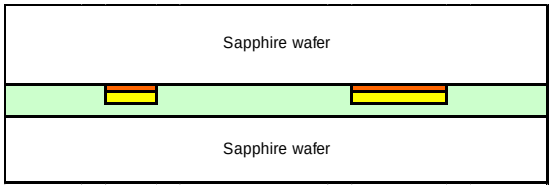
The nanoform represents a dramatic advance in long term data storage technologies; with several specific advantages in comparison with numerical or physical solutions that are used today:



- durability of the access to information: the information is maintained in an analogic and un-coded form, it is easily read thanks to simple optical techniques, based on unchanging physical principals; the information will never be impacted by the triple obsolescence of numerical techniques, i.e. the supports (very low lifetime of the CDs, DVDs, disks, etc…), the software, and the equipment (new systems and peripherals).
- preservation of the information stored with a high security level, and very low storage cost: the nanoform is resistant to biological, chemical, physical (light, radiation), mechanical, heat and water attack due to the innovative use of sapphire substrates. For example, sapphire has a very high chemical immunity and can resist immersion of more than 500 years in a chemical mixture comprising hydrofluoric and nitric acids.

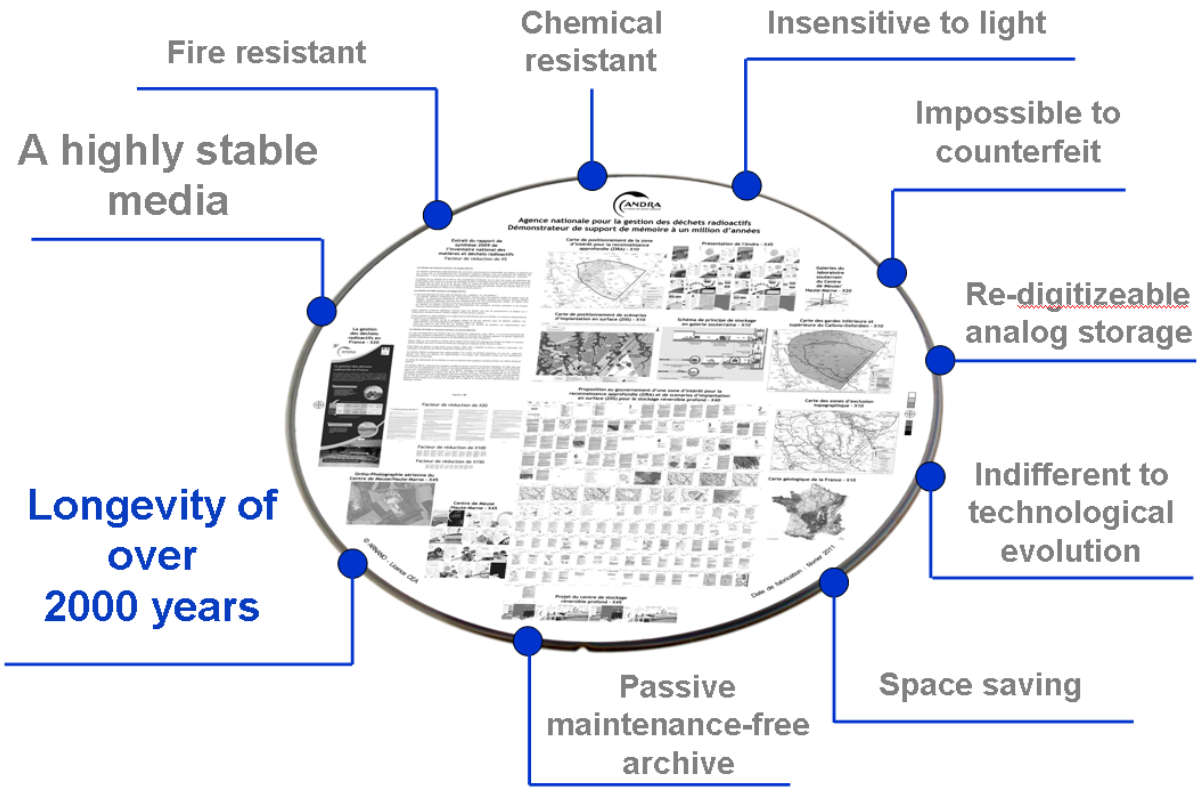
Therefore, in comparison with current classical approaches, the nanoform will not need any particular environmental storage condition (except for mechanical protection against risk of a buildings collapse due to earthquake etc.)

In addition to innovative product features, the nanoform also comprises several technical innovations.



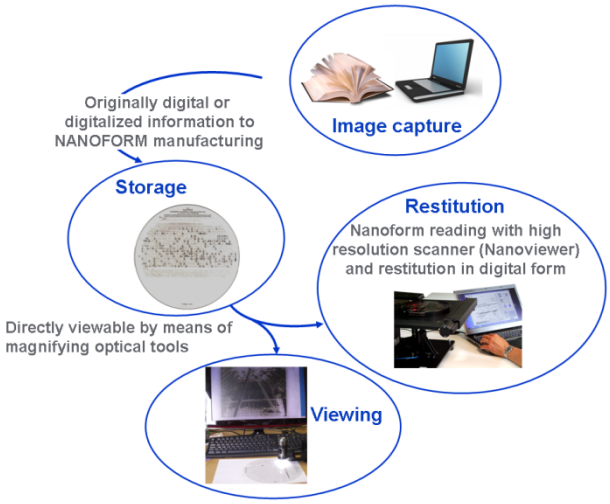
Schematic representations of a nanoform, and example of realisation

- The nanoform offers the possibility of reproducing any document in various grey levels, and even in colours, by separately storing the images of each fundamental colour (For example : Red Green Blue).
- The information storage density is 20 times higher than that of a standard A6 microform. It is possible to store the equivalent of 10 000 A4 pages on a single 200mm sapphire disk!
- The reproduction in not forgeable: indeed, the data embedded within sapphire cannot be changed mechanically (scratching) or chemically. It could in principle be destroyed by a high power laser, but proof of the intervention and of the forgery would then be perceptible.
- The manufacturing process involves lithography already used for microscopic text writing (7, 8, 9). The two main technological advances rely on the choice of the materials and the use of a specific process. The precious and refractory metal layer, on which the information is engraved, is buried between two sapphire wafers stuck together by molecular bonding. These are both protected by patents (10).



The process

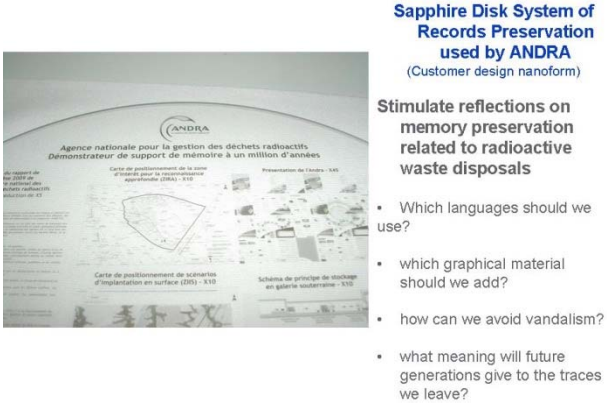
The complete manufacturing process is available



- data capture : under native digital form or any document that will be be digitized
- organisation of the data on the storage media (with summary, metadata and any format or resolution)
- data treatment in black&white, gray scale or colour (by decomposition on the basic colour Red, Green, Blue)
- nanoform manufacturing with writing process by maskless laser lithography system and engraving etching buried by molecular bonding of two sapphire wafers
- scanning of the data from the nanoform, in order to retrieve the information on paper, on line, or on any computer media.

Market and ANDRA example

The target market is long term preservation, with a high level of security of data of a precious, security, statutory or even emotional character:

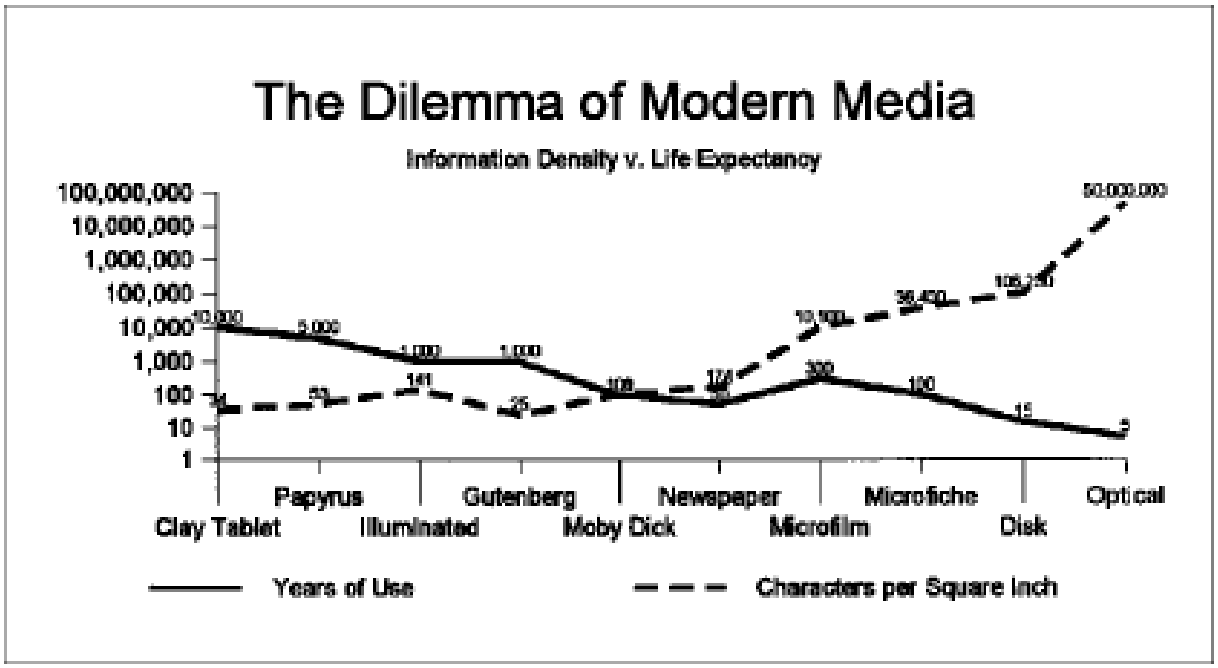


- Precious: data of concern here are data presenting considerable value for societal or corporate needs. For example, the preservation of an image of human cultural heritage; targets are UNESCO, museums, libraries, INA (French National Audiovisual Institute). From a corporate needs perspective, immediate targets are news agencies or companies having very long term data storage commitments (EDF, AREVA)
- Security: data of concern here are data for the traceability of information requiring security, such as storage of ultimate waste (irradiated material). The ANDRA (French national agency for the management of radioactive waste) and its international homologues are long-term targets.
- Statutory: data of concern here are data that companies must statutorily keep in the long term, for example banks, solicitors, auctioneers …
- Emotional: individuals may wish to pass on personal information to offspring in a "time capsule-type" approach.

The individual elements of the ultra long term data storage nanoform, which represents a dramatic breakthrough in storage, offering the possibility of media with lifetimes longer than several thousand years, has been completed and qualified through extensive reliability testing and meets the highest standard.

Supporting documentation

1 – The dilemma of modern media - The Long Now Foundation http://www.longnow.org/



2 - Franck Laloë, « Documents numériques : attention, fragiles », Pour la science – N°361, novembre 2007

3 - Jonas Palm, « The digital black hole » - Stockholm – Sweden

4 - Jill Barson Gilbert, « Digital data archives…etched in stone? », Air & Waste Management Association - april 2006

5 - Long Now Project warning about the possibility of a « digital dark age »,
Danny Hillis – 1996

6 - Svalbard Global Seed Vault : biodiversity 'Doomsday Vault' comes to Life in Arctic - PIERRE-HENRY DESHAYES - Agence France Presse - 24feb2008

7 - Nanoark http://www.nanoarkcorp.com/

8 - Graphilux International http://www.crystal-bible.com/index.htm

9 - Norsam Technologies http://www.norsam.com/

10 - The engraving technology is protected by 2 international patents:

- WO 2009/092794 A2 «Object provided with a graphics element transferred onto a support wafer and method of producing such an object » 23 January 2009
- WO 2009/092799 A2 « Object comprising a graphics element transferred onto support wafer and method of producing such object » 23 January 2009

Discussion Notes

S. Tucker asked if you could dispose of the original paper archives once a disk had been created, and how much one would cost.

On the first point, A. Rey said that this was the case in so far as the National Archives of France recognized the disk as an available option, although they cannot recommend a commercial product. With regard to cost, each disk would be around three to ten thousand euros.

M. Buser remarked that the techniques on display were very advanced – but we need to recognize that the information we leave may not be interesting for future generations, so we need to think about context. He suggested that the end of the 'nuclear age' may have a similar effect on nuclear knowledge as the Enlightenment had on medieval scholarship – it will become lost because it is not valued or respected.

SESSION 7 – ARCHIVES: NATIONAL, TRANSNATIONAL AND SUPRANATIONAL

31. Current procedures on documentation and archiving

Overview of member responses to a questionnaire

Anne Claudel, Nagra

Background

At the RK&M project meeting on 10-11 April 2012, it was recognised that specific information needed to be collected on record management and archiving as applied to waste management facilities. The participants in the RK&M project were therefore asked to write a short summary on current procedures and planned activities for documentation and archiving in their organisations.

The following topics of interest were identified:

- Types of information and documents archived by implementer/regulator
- Main archiving formats (paper, digital, other)
- Language of archived documents and information
- Are there limitations to the archiving time of some records?
- Are archiving plans with specific prescribed minimum archiving times for different kinds of documents used or not?
- What are the current selection criteria (if any)? Who sets the criteria?
- Is there a policy for the periodic migration of electronic documents?
- Is transfer of archived information from implementer to regulator, to The National Archive or to any other authority or body required (legislations, etc.), planned or discussed and if so to whom, what, how and when?

Responses from 9 countries and 11 organisations were received: Belgium (ONDRAF / NIRAS), Canada (NWMO), Czech Republic (RAWRA), Finland (STUK), France (ANDRA), Germany (GRS), Sweden (SKB & SSM), Switzerland (Nagra & ENSI) and UK (NDA).

The varying scope and level of detail of the responses did not allow an analysis of the results in terms of trends or most current practices. The list of findings below therefore features a series of general practices.

Current findings

It was found that guidance on archiving, including guidance on which documents should be archived and for how long, is often derived either from general archival standards – produced by the national archives – or from existing requirements applying to NPPs. As a result, guidance usually remains fairly general, e.g. stating that all "relevant" information should be kept. The development of specific guidance on practical implementation is often postponed to later stages of repository development, i.e. when the need for long-term archiving becomes more concrete.

With respect to current information practices, there is a distinct preference for long-term archiving in analogue format (permanent paper / microforms / objects). However, full digital archives are also planned in some cases, either by the regulator or by the national archives themselves. Archiving language is by default the official language of the country.

Regarding the records management process itself, archiving plans are usually in place for current activities. Retention periods requested by existing (mostly generic) regulations apply to some types of records and typically range from 10 to 100, sometimes 300 years. However, in most cases records should be kept "permanently".

The transfer of records to the national archive after repository closure is foreseen in the regulations of the majority of countries. In the case of government organisations, national archives tend to be involved in the process from the beginning and start to collect records much earlier. The need to set up a separate, dedicated "National Nuclear Archive" is mentioned by the United Kingdom only. Most organisations reckon that the migration issue will be dealt with by the (national) archive. The need to keep archives in more than one location is mentioned in the legislation, but rarely (yet) put into practice.

Conclusions

When analysing the responses to the survey, it has become clear that some topics would need to be investigated further, in particular institutional options for long-term archiving (national, international and dedicated archives). More specific questions will also need to be asked regarding issues that have not been mentioned in the responses, but may have indeed been addressed in the various organisations. This is in particular the case for the need to compile, at different stages of the disposal process, documentation at different levels of detail (see IAEA 1999).

Regarding work methods in general, the various questionnaires completed by the participants since the beginning of the project have yielded interesting, albeit heterogeneous results. The responses to the archives survey sometimes duplicate, at least partially, information collected previously. Indeed, waste management programmes at an early stage of implementation can often do no more than list existing regulations. At this point, the usefulness of further surveys addressed to all participating countries may be questioned. Having one person, or a group of persons, address a particular topic and report on it may lead more satisfactory results.

International Atomic Energy Agency (1999): Maintenance of records for radioactive waste disposal. IAEA-TECDOC 1097. IAEA, Vienna.

Discussion Notes

J. Schröder asked if there was any information on what was kept at present, and if we could use that knowledge to also investigate why that specific information was kept.

A. Claudel replied that currently, countries seemed to be keeping everything, 'just in case'. The criteria are very broad, as the regulations require, for example, 'relevant information' to be archived.

32. UNESCO's Memory of the World Programme

Joie Springer, Memory of the World, Communication and Information Sector
UNESCO

Knowledge is a prized possession that needs to be preserved for transmission to later generations. However, whether it is recorded on clay or stone tablets or papyrus scrolls; in manuscripts or books; in the form of photographs, film or sound recordings; or accessible through modern media such as blogs and the Internet, this legacy is fleeting and faces the risk of disappearing without a trace. The causes are many: war and social upheaval, natural catastrophes, chemical deterioration, technological obsolescence, wilful destruction, neglect and lack of funding. These have all caused the loss of significant documents around the world.

When UNESCO was created, its founders assigned it the mandate to preserve knowledge in all its forms. In 1992, many countries approached UNESCO for assistance in preserving their recorded heritage, and in order to meet their requests, UNESCO assumed a leadership role and decided to establish a global mechanism to safeguard all forms of documentary heritage. It therefore created the Memory of the World Programme with the stated objective of preserving and protecting the world's memory, in the form of its documentary heritage, for the benefit of all.

This memory is a shared, common legacy that is important for both current and future generations. Under the Programme, UNESCO implements preservation projects, conducts training workshops and provides technical advice on preservation and access issues as it seeks to build awareness of the contribution of documentary heritage to efficient and accountable management and governance, and to education and sustainable development. To achieve its objectives, the Programme (http://www.unesco.org/webworld/en/mow) operates at the international, regional and local levels to ensure that no matter the means of recording memory, universal and permanent access to it can be assured.

Preservation is therefore a major priority of the Programme, and to encourage efforts in this field, the UNESCO/Jikji Memory of the World Prize has been awarded biennially since 2005 to outstanding preservation efforts. The Prize commemorates the inscription of the *Buljo jikji simche yojeol*, the oldest existing book of movable metal print in the world, on the Memory of the World Register, and was established to reward those who have contributed to the preservation and accessibility of documentary heritage as the common heritage of humanity.

Access is the other key element of the Memory of the World. Through its international register, which currently lists 245 items from most countries in the world, the Programme enables the intellectual treasures that have been created by all cultures and in all regions to be better known. Access is also facilitated through cooperation with the World Digital Library, a joint UNESCO/Library of Congress initiative that promotes access to significant collections held anywhere in the world.

Each country is encouraged to establish its national register and items listed can be recorded on any of the carriers used to safeguard memories. They may be listings of archives relating to famous people and events; exploratory voyages that have had lasting impact on the world; scientific discoveries that have transformed the world; or anthropological recordings of extinct societies, etc.

Knowledge can be recorded and stored on in a variety of ways but all are endangered to a greater or lesser extent. While methods of preserving knowledge recorded in print and analogue media are well known and implemented across the globe, the same is not necessarily true with respect to digital documents and records. These becoming the main source of transmitting knowledge today, yet their permanence and authenticity are at risk

One of the major global misunderstandings is the assumption that digitization means preservation, when in fact it is only a small part of the process. Through its Memory of the World Programme, the Organization consequently continues to stress that preservation of digital information requires a

permanent logistic and financial commitment in order to remain accessible. These issues are spelt out in the UNESCO Charter on the preservation of digital heritage which guides policy decision in this field, and will be further explored in Vancouver, Canada from 26 to 28 September 2011 during an international conference entitled "Memory of the World in the Digital Age: Digitization and Preservation".

The means of safeguarding digital documents are significantly different from those employed for 'traditional' documents. At the same time, few countries have as yet adopted a national policy regarding digital information, and remain unaware of the risk of disappearance of commonly used means of transmitting and storing digital information, such as email, databases, and websites.

The conference will help to explore the main issues affecting digitization and digital continuity, in order to develop a strategy for the protection of all types of digital documents, and define implementation policies that are sustainable and globally applicable, especially where developing countries are concerned.

The Memory of the World was established to mainstream documentary heritage so that the need to safeguard knowledge, and the work that goes into its preservation, will become more visible and enduring.

Discussion Notes

A. Claudel commented that access was what preserved heritage.

C. Holtorf ask who the World Register intended its audience to be – the present, or the future? Did J. Springer anticipate that the register would be of value to those in the distant future?

J. Springer replied that it was intended both for now and the future. Contacts are maintained both with professional institutions and the general public – it is open to academics, information technology professionals, and anyone with a general interest in the preservation of knowledge.

J. Springer added that she thought the format of the register would change – for example, there was currently an effort to catalogue the output on social media sites. However this goes back to the idea of storing information somewhere.

J. Schröder asked if the register had any records comparable to those being discussed in this RK&M project.

J. Springer replied that, because of the way the programme developed, there has been a focus on items of historical and cultural value. However, they also have items of scientific importance such as medical manuscripts. The aim is to cover all areas of human thought and endeavor.

W. Ernst commented that there has been a general move away from traditional archives to decentralization, and asked if there was any reflection in UNESCO of replacing the central register with a more dynamic method.

J. Springer responded that these changes were led by recommendations from the member states. It is generally more reactive than proactive as a process.

C. Pescatore asked group members to check if INIS has their important documents on file. A. Claudel added that as INIS was a bibliography database for published material.

33. INIS and its national implementation

Jantine Schröder – Alain Sneyers (SCK•CEN)

This presentation provided an introduction to INIS, the International Nuclear Information System, developed and operated by the International Atomic Energy Agency (IAEA). Both the presentation and this abstract are based on information from the INIS website (http://www.iaea.org/inis/) and on insights from the Belgian national liaison officer.

What and why

INIS is one of the most comprehensive information systems on the broadly conceived theme of peaceful uses of nuclear science and technology. The system operates and maintains a bibliographic database and a collection of full-text documents including non-conventional literature (NCL). "Non-conventional" or "grey literature" are publications that are not easily available from regular sources, i.e. publications with limited (non-commercial) distribution (e.g. internal research reports, project milestones that feed into deliverables but are not published as such, …).

The INIS database currently contains over 3.3 million abstracted and indexed records and a comprehensive collection of over 600,000 full text NCL documents (retrievable online or via electronic document delivery). Every year, around 120,000 new records are taken up in the system.

INIS was established in the late sixties, in line with the general mission statement of the IAEA: the promotion of the peaceful use of nuclear energy. It started operation in 1970, in a context that reveals much of its 'raison d'être' at the time: Interactions between East and West were limited, and in an era without the internet, exchange of scientific-technical information had to go mainly through printed media or live interaction. INIS' coming into being was also set against the background of the research boom of the early years of nuclear technology (40 – 50 – 60ies): for divergent reasons, various options and research tracks were not pursued further (e.g. related to reactor research), but turned out to be interesting again later (this happens still today). This research was also often linked to specific people or research institutes, and thus accessible only to a limited degree.

The basic reason for the existence of INIS has remained the same over time, namely to foster research and development, to give access to a trusted nuclear information reservoir, to serve the information needs of both developing and developed countries, and to develop and preserve not only information itself, but also information management competency. The IAEA formulates the objectives of INIS as follows: *"Assist Member States in ensuring the management and preservation of nuclear information and knowledge, needed for the effective and safe use of nuclear energy and its applications for future generations"*, which clearly shows its relevance for the RK&M project.

INIS' scope has obviously evolved with time. The main INIS activities today include

- INIS Database Updating and Management
- Computer Assisted Indexing
- Preservation of Non-Conventional Nuclear Publications
- Creation of the INIS Multilingual Thesaurus (over 30 000 terms)
- Capacity Building (Training and Distance Learning)
- Providing progress and activity Reports

The scope of themes has also expended over the years, including topics from nuclear physics to economics, from agriculture to social aspects, from engineering and instrumentation to safeguards, and almost everything in between.

Mode of operation

INIS is operated by the IAEA in close collaboration with its Member States. The IAEA provides the INIS Secretariat with about 20 members of staff and supports its day-to-day operation; its 128 Member States and 24 International Organizations provide the input to the system. Partnerships exist with the OECD Nuclear Energy Agency (NEA) and the International Energy Agency (IEA). Members' contributions to INIS are mainly provided by nationally appointed liaison officers. They undertake the responsibility for organizing the collection and preparation of literature input from their Member States or international organizations, provide the INIS Secretariat with advice on matters relating to the administration, operation, and development of INIS, and are responsible for the dissemination of INIS products through their information services and for promoting INIS products and services in their countries / international organizations.

The INIS process is organized as follows:

INIS Members collect and prepare input for the INIS database (i.e. nuclear literature published/written in their country/international organization) in a standardized format conforming to specific guidelines; they draft abstracts and index nuclear literature, and then submit this bibliographic input to the INIS Secretariat in electronic form.[21] The INIS Secretariat verifies all incoming records. The indexing and abstracting of records is subjected to a continuing quality control based on an Expert System. This system identifies records with a high probability of error for scrutiny by subject specialists of the INIS Secretariat. Their corrections and comments are passed on to the subject specialists in the national INIS Centers. The Secretariat staff then processes and converts records by programs into an internal working format, and creates the final consolidated output files in the INIS exchange format (ISO-2709) for upload in the INIS database for online and CD-ROM retrieval.

Some thoughts on benefits and limitations

INIS offers an enormous, dynamic and up to date database of bibliographic data and full texts of non-conventional literature. Bibliographic data in the INIS database are enhanced with metadata (subject categories and indexes, and a very large thesaurus) allowing for targeted database queries and literature searches. In other words, it is quick and easily accessible. Moreover, INIS continually evolves and adjusts to technological information requirements, the needs of its users, and new information management practices. The training it offers its members ensures that not only technologies, but also human skills are developed and maintained.

On a more generic level, the role of bibliographic databases thus is clear, as bibliographic data and publications are a key resource of scientific-technical records and play an important role in the management and the preservation of information, and also in the framework of RWM. The benefits of an international approach lie predominantly in the development of a common approach and the sharing of resources and knowledge (cost-effectiveness / economic benefit).

However, the system also has its limitations. Firstly, INIS is a co-operative system depending on contributions from its membership. In theory, each member is expected to analyse and input the full scope (all sources, all themes) of national literature. Most members have 1 or 2 liaison officers who can mostly rely on the help of the staff of their library or knowledge center. Larger countries may have a few full time equivalents (FTE) working for INIS, but for smaller countries it often comes down to only a fraction of the number of FTE. For countries that fail to meet the expectations, the INIS Secretariat at IAEA steps in, but exhaustive coverage is simply impossible in practice. Apart from man power, INIS has to deal with copyright limitations due to which certain abstracts or full copies cannot simply be copied and processed into INIS.

More generally, it needs to be acknowledged that INIS is operated as a bibliographic database consisting of individual indexed records; no less but also no more. INIS is not conceived as a knowledge management or expert system providing access to basic information or to layered information, providing a broader picture and relationships between individual records or information elements. In the framework of the RK&M project (cf. mission statement and glossary), INIS can perhaps better be described as a set of records than a knowledge system. It may enhance memory preservation, but perhaps only for a certain audience and only if promotion is successful. Arguably, it would take quite some effort to reconstruct ‘a story’ out of such a records database. With regard to the RK&M project, it should obviously also be mentioned that INIS does not focus on radioactive waste management; this is but one theme among many others.

In summary, to fully serve the framework of the RK&M project, INIS thus may be limited with regard to the provision of both basic information and the ‘broader picture’, by means of structured access to

[21] Most input centers utilize the PC based input preparation package 'FIBRE' (Friendly Inputting of Bibliographic Records).

detailed information including relationships and thus the 'logic' between individual information elements or records. It may also be restricted with regard to serving different target groups and audiences (specialist and non-specialist). It thus seems that these aspects should be further addressed within the RK&M project.

34. NEA Data Bank: Knowledge Preservation Activities

Ian Hill, NEA Databank

The OECD Nuclear Energy Agency Data Bank was established by its member countries as an institution for the collection, verification, validation, dissemination and enrichment (through user experience and feedback) of the basic tools used today for nuclear energy system design and the simulation of their functioning under different operating conditions. These tools comprise standardised databases with microscopic basic nuclear and chemical-thermodynamic data, computer programs for a wide range of applications, integral experiments on fissile material systems, reactor or radiation shielding mock-ups and in-core fuel behaviour.

The main areas of work of the NEA data bank are as follows:

- Maintaining and collecting basic nuclear tools, such as computer codes and nuclear data;
- assisting member countries in preserving know-how;
- providing support for knowledge preservation efforts.

Data Bank: Nuclear Data

Nuclear data priorities of the data bank are compilation, dissemination and co-ordination of international effort to further improve nuclear data. In order to accomplish this goal, the NEA is currently:

- compiling experimental nuclear data;
- collecting evaluated nuclear data and bibliographic information;
- exchanging of nuclear data of all types with other data centres;
- promoting the development of special purpose evaluated data files;
- developing common formats for computerised exchange of nuclear data;
- co-ordinating the development of computer software for managing and disseminating nuclear data.

The data bank is one of the four core centers of the NRDC (Network of Nuclear Reaction Data Centres), the others being the US National Nuclear Data Center (NNDC), the IAEA Nuclear Data Section (NDS), and the Russian Nuclear Data Center (CJD). These core centers each coordinate world-wide services covering the entire range of nuclear data duties and interface with national and specialized centres.

Context of the role of nuclear data
Measurement of nuclear reactions at each energy source for all nuclides is a time consuming and expensive process. If knowledge of the fundamental measurements were to dissipate, decades would be required to reproduce the current state of knowledge. This knowledge is contained in both the raw experimental data, as well as the evaluated nuclear data libraries and is exchanged between countries.

Information exchange and coordination EXFOR
Fundamental nuclear experimental information is shared between countries via 14 Nuclear Reaction Data Centres (NRDC). These centers are responsible for translating nuclear data measurements from literature sources, into a common exchange format (EXFOR). Responsibilities are divided between the centres by both geographic location and nuclear reaction. Once the experimental information is

translated into the EXFOR format, the files are sent to the other centers, which verify the submission. Historically, each of the four core centers maintained a master file for their geographical area and held copies of master files of the other three core centres; however, in the early 2000s to improve

synchronization, the IAEA-NDS was given responsibility for the EXFOR master. The NDS now maintains the master and sends a copy to other data centers approximately every two months. The EXFOR copy is stored identically to other data bank files, as will be discussed in the computer program library section.

While each of the countries has access to much of the same experimental information, different evaluated nuclear data libraries are produced by both national and international organizations. These include the NEA Data Bank Joint Evaluated Fission and Fusion library (JEFF), the US Evaluated Nuclear Data Library (ENDF), the Japanese Evaluated Nuclear Data Library (JENDL) and others. Nuclear data evaluation is referred to as part art, part science, thus the existence of different interpretations of the measured differential and experimental data allows for cross checks, which have greatly improved the quality of each of the evaluated libraries.

Development of nuclear data tools
To improve accessibility/dissemination of nuclear data, the data bank has developed tools to visualize and interact with the data. One example of is the software tool JANIS, which amalgamates features for viewing both EXFOR and various evaluated libraries. Owing to the enormous amount of data and the tedious/complex format (for humans), many for the nuclear data centers have developed tools to interact with the data. A recent example is a checking code developed to identify errors in the EXFOR data.

It is sufficient to note that the data centers each attempt to lower the barriers required to both understand and utilize the stored information.
Survival of nuclear data during moves

Each move of the nuclear data center, from Saclay, to Issy-les-Moulineaux, and subsequently from the 9th floor to the 5th floor of the same building, resulted in a loss of an archive, which eventually was found to have contained valuable information. An example is that no copy remains of the original Joint Evaluated File JEF-1. The loss of evaluated nuclear data files does not appear to be a unique phenomenon, for instance, is there a copy of the original ENDF/B-I library anywhere?

Data Bank: Computer Program Library Services

Role of computer codes in a RK&M context
Computer codes themselves represent significant collections and amalgamations of knowledge. Codes can encapsulate the state of knowledge in a field, while version updates reflect a dynamic state of knowledge. Implicit knowledge is also present in codes; a successful code must agree with external experiments and data. Moreover, due to the cost and time associated with experiments, reactor physics and safety experiments are becoming less common and as a result there is an increased reliance on codes to act as surrogates for experiments. Nowadays an engineer may base his judgement solely on the results of a code.

If knowledge of a particular area is to be resurrected a computer code may represent a more complete set of knowledge than any existing reference document.

Collection and distribution
The data bank obtains computer programs either by the donation of the organization that created the program, or via agreements with the Radiation Safety Information Computational Center (RSICC) or the IAEA. Once received, programs are stored on data bank computers and can be subsequently retrieved from the data bank, thus the data bank functions as a library, rather than an archive. A list is maintained of all code recipients that dates back to the beginning of the computer program library services (~1964). Retrieval of programs is done via liaison officers of nominated institutions in data bank member countries, while IAEA member countries can retrieve codes by contacting their IAEA representative who then makes a request to the IAEA liaison officer; additional restrictions may apply. The use of liaison officers transfers onus of responsibility to individuals, who must ensure that data bank procedures are followed, or face having their access rights revoked. Contact with data

bank customers is maintained through electronic bulletins, which highlight data bank acquisitions, both codes and other data, such as legacy texts or integral experiments. Additional details can be found on the website, http://home.nea.fr/dbprog/service.htm.

Testing and Q/A
Most provided codes are installed and tested at the NEA, while a smaller number are tested externally by contractors. Testing ensures that the code produces the intended results as outlined by the originating institution. The tests include both the installation of a program and the execution of a provided verification suite. Once a code has been tested, the code abstract is placed on the data bank website. The data bank also ensures a standard of consistency with other code descriptions and that the verification suite is adequate.

Typically the number of requests for a code is inversely proportional to the time from the initial release. Inevitably the data bank holdings include codes that were compiled on platforms which are not so easily accessible. The data bank preserves all information about the code, which in some circumstances can be used to replicate the output of a discontinued binary library.

Other codes are supplanted by an updated version. While the NEA removes legacy versions from the publically displayed distribution list on the website, it does keep legacy versions; these can also be retrieved upon request.

Storage
When the NEA receives a code, a copy is made on a CD or DVD, as well as stored electronically on two spatially separated synchronized servers, thus there is a redundancy of storage formats. The data bank also stores the codes electronically in three different computer formats; for instance, codes are stored unzipped, in dos zip format, and in linux tar format. Also, the data bank retains hard copies of the user manuals.

Backup procedures for the codes are done in conjunction with the backup of all NEA data electronic data.

No special priority is given to computer programs; personal files stored on the NEA network drives are given the same priority as NEA codes, resulting in a backup that is roughly 5TB in size. Daily, an incremental backup is done on two redundant machines, which are located on different floors in the same building. Once a month a full backup is performed and the tapes are physically moved to an offsite storage location and the tapes from the previous month are returned. Tapes are stored for thirteen months.

Institutional collapse
A majority of data bank holdings are available through RSICC (nearly 100% for recent codes), so if the data bank and all holdings were to vanish overnight, many of the codes would still be retrievable if agreements were put in place. A small number of other distribution centers, albeit with a lesser number of holdings, also exist. Of course, distribution of the codes assists in preservation, as each recipient holds a copy making the absolute loss of a code less likely. Notably, the data bank could use its distribution records to contact users; however the list may not survive an institutional collapse.

Data bank human resources Notes, Center of Competence:

When the data bank was initially formed in 1978, the staffing level was 27; this was a reduction of the aggregate of 31 staff at the two institutions which merged to form the data bank, namely the Nuclear Data Compilation Center (CCDN) and Computer Program Library (CPL). Currently the data bank staffing levels are constant at 17.4 actual staff, plus 7 frozen post and project posts. Previous roles of the data bank employee have been outsourced via external contracts managed by the data bank, which from an organization point of view, presents problems in terms of knowledge management.

Some fields, particularly in the area of nuclear data, have seen the number of people with the required expertise decrease to critically low levels. Since the data bank acts as a 'hub', its staff has

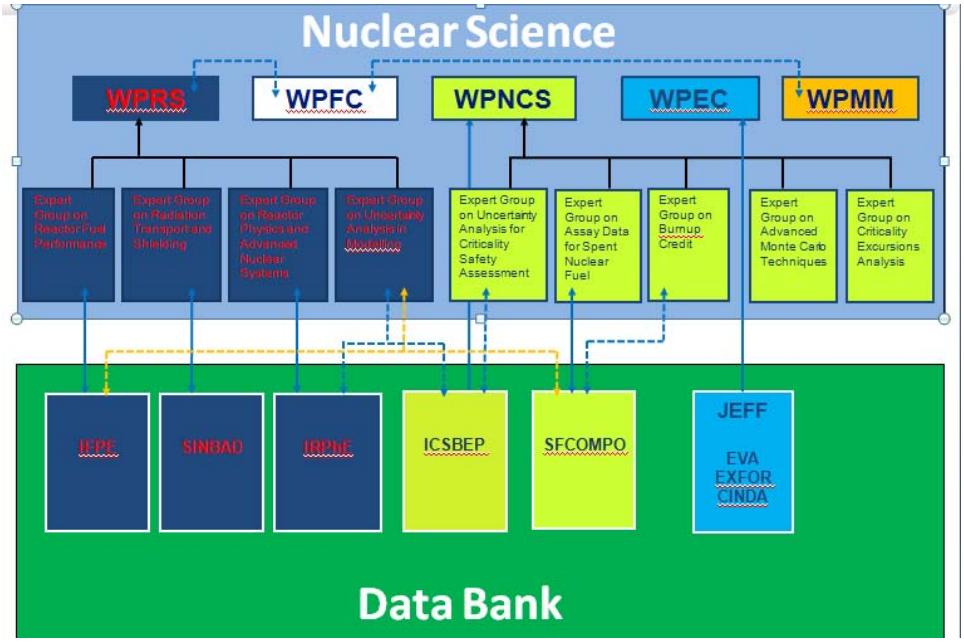
access to a network of international experts, as well as direct interactions with specialised organizations. Accessing these networks plays an increasingly vital role, as countries and institutions may no longer chose to maintain sufficient internal expertise. Notably, human resource turnover is relatively high at the data bank. Higher turnover results in a greater number of individuals possessing insider knowledge of the network of expertise and interactions between institutions. However, a high turnover rate also carries risks, as maintaining continuity of knowledge between employees may be difficult, notably in areas of work that are not documented within procedures. This is especially true when aspects are based on soft skills such as human relations that are not easily transferred between people, as is the case for a number of data bank positions.

Using the Data, Interfaces of Data and Knowledge: Interactions with NEA programs of work:

The data bank also interacts with various NEA programs of work. Critically a synergy exists between the data bank and areas such as the Working Party on International Data Compilation (WPEC), which identifies and addresses needs in the area of nuclear data.

Other interactions include interfaces with the nuclear science committee program of work. This results in the generation of handbooks and databases held by the data bank. The various programs of work also make use of data bank holdings, both nuclear data and codes, raising the profile of the data bank holdings.

A diagram of the interaction between the data bank and the nuclear science committee is seen below:



Case study: International Criticality Safety Benchmark Evaluation Program

The ICSBEP program is an example of knowledge preservation. This activity preserves legacy criticality experiments, in order that we need not repeat the integral experiments. Since each criticality experiment is expensive and becoming more-so (a recurring theme), it is sensible that each country need not repeat the same experiments. Thus remembering the past and sharing information leads to cost savings and the ability to better identify areas which need additional focus. The ICSBEP project classifies knowledge management as having four levels:

1. Archive
This involves bringing the raw experimental reports to a safe haven, or changing the format from paper to electronic.

2. Compilation
During this phase the experimental reports are transformed into a strict format as designated by the ICSBEP format guidelines. Adherence to the format ensures that future users will be able to quickly search the document for the required information and that a single document will encapsulate all the relevant information required.

3. Interpretation + Review → Handbook (NEA facilitates expertise reviews and yearly meetings)
This critical step involves bringing together international experts to verify both that the compilation is technically accurate, and also that it meets the ICSBEP format. These experts also contextualize the evaluation, by noting how the results 'fit' with other previously compiled benchmarks.

4. Databases
Once a critical mass of data is accrued, the data bank can create a relational data base to allow searching and interrogation of the data. The interactive use of the data improves the transfer of knowledge to a broader audience than just the expert group.

Discussion Notes

I. Hill confirmed that the Databank also held radio toxicity codes.

Regarding the compatibility with INIS, I. Hill explained that the Databank had an INIS liaison officer who provided abstracts for INIS, and added that INIS was more globalised and generalized than the Databank. The Databank aims to maintain a 'sharp saw', which can be used for any kind of analysis.

35. UK Nuclear Archive Project

Simon Tucker

When the Public Records Act was first passed in the UK in 1958, records and archives were not widely used as a resource by the community and their importance to a wide cross-section of society was not as apparent as it is today. Most Government records were on paper and the impact which digital storage would have on record keeping and access to archives was not foreseen. The importance of records as evidence of Government activity is much more widely appreciated today. New legislation on Data Protection and Freedom of Information gives us the right to see information and records on a wide variety of subjects. These records, and easier access to them, enable us to meet a reasonable expectation of a democratic society that government should be accountable for its actions. Records and archives make a valuable contribution to the Government's important policy objectives, including modernization of public services, open and accountable government and education. They help enable all public sector bodies to meet new and demanding standards of corporate governance and are essential underpinning to meeting auditing requirements and validating performance in many important areas of work.

The 2004 Energy Act in the UK saw the formation of the Nuclear Decommissioning Authority (NDA). Subsequent legal Transfer Schemes ensured that, with minor exceptions, all the relevant data, information and records relating to the civil nuclear decommissioning industry were now owned by the NDA. This has led to the creation of an Information Governance Strategy that encompasses all elements of Information Management, Knowledge Management, Information Risk Management, Strategic ICT and Intellectual Property Management. Information & Knowledge Management specifically have also been classed as a 'critical enabler' to all decommissioning activities and thus embedded as key deliverables in the contractual relationship between the NDA and the Site License Companies (SLCs).
Core to the successful delivery of the Information Governance Strategy is the establishment of a National Nuclear Archive (NNA). When the NDA was established in 2005, The UK's National Archive

(TNA) was approached and consulted in the plans to develop an effective archiving process. Given the nature (often protectively marked) and volume of records expected to fall under the 'Public Record' definition, TNA agreed that the NDA managing the archiving and long-term records management processes was the most appropriate solution in principle and committed to assisting with the project by providing professional advice. As set out in NDA's overarching Strategy document at that time, the broad aim is to preserve as a consolidated archive, enabling access to stakeholders representing a very wide range of potential user interests, a wide range of documents (including text, microfilm and visual images) relating to the history of civil nuclear energy development in the UK from the 1940s onwards. NDA's challenging mission and long planning timescales are compounding uncertainty about information needed for safe decommissioning. Thus, an effective Knowledge Management programme will also need to be developed and deployed, and the NNA's role will be a key component of this.

The Challenges

Significant numbers of NDA records date back over 70 years, and a great deal of manpower intensive effort will be required to sift and index them, much of which can only be done by subject matter experts in the SLCs. Across the NDA Estate, there is no clearly defined policy for the destruction of records and sample surveys show that much that is being stored is duplicated or available elsewhere and could be destroyed thus reducing the overall Records Management cost. Furthermore, the use of digitisation is not widely established across the NDA Estate, and the current practice is focused on expensive storage of paper records, but often not in a way that properly protects documents for the medium or long term. The precise size of the records storage task is unknown as no comprehensive audit has been carried out across the NDA sites. Equally, the balance between which documents must be stored in hard copy and those that can be digitised is unknown, which presents a challenge in sizing facilities needed for archiving. Overall, it is currently estimated that the medium to long term NDA archiving task is around 24 linear km of records and this includes records classed at the highest levels of protective marking in the UK.

Another challenge exists in establishing an Information Governance aware culture across the nuclear industry in the UK. With respect to the establishment of an effective archiving solution, chief amongst these challenges are:

- Creating appropriate and effective strategies, policies and procedures (applicable to a number of entirely separate organizations) for dealing with all records, whether physical or electronic, in whatever format they exist and in all states of (dis)repair;
- Compliance with relevant statutory and regulatory obligations;
- Digital Preservation;
- Accessibility vs. security. The nuclear industry has always and will continue, for very good reason, to operate on a 'need-to-know' basis. The Information access laws in the UK challenge this and the effective management of the Archive will be central in ensuring that the correct balance is struck on behalf of all stakeholders;
- Effective re-use;
- Active vs. inactive storage;
- Long and very long-term Records Management in support of radioactive waste records, land contamination records, a Geological Disposal facility, etc;
- Costs.

The Solution

The NNA will be a centre of excellence managing all of the Information and Knowledge Management compliance requirements mandated on the NDA for the short, medium, long and very long-term. It is envisaged that this new organisation will manage all of the semi-active and inactive records

management requirements for the Estate (active records need to remain with the site license holder until no longer required) together with being the subject matter expert in addressing many of the challenges such as; Digital Preservation, Access, Security, Digitisation strategies, long-term Archive management and others detailed above.

Plans for the building of the UK's NNA are well advanced with final sanctioning now being sought from NDA's Executive team and Government. It is envisaged that, whilst the NDA will build the facility itself, it will work with a commercial partner(s) in the 'fit-out' and operation of the facility.

The current programme indicates that the NNA will be operational in 2016.

Discussion Notes

S. Tucker commented that 'permanent' storage meant the the need for the record did not need to be reviewed at any point – it did not mean that the record was expected to be kept forever.

S. Tucker also returned to R. Ferch's comment that for some questions on this topic, there were very few answers. The UK programme, S. Tucker held, would provide some answers for,

- The cost of knowledge management
- The role of the NGOs
- Monitoring and the necessity of active management
- Security concerns

It was asked if the need to support the community at Caithness, home of the Dounreay site, was one of the reasons behind choosing to build the archive in that area.

S. Tucker confirmed that this was the case, as the NDA had an obligation to invest in areas that were supported by the nuclear industry, where the sites were now being decommissioned. Additionally, there was already a significant collection of records at Caithness.

I. Hill asked if documents held at the National Archive at Kew were to be transferred back to Dounreay. S. Tucker said that this was partly the case, depending on copies and availability. He added that these documents would be better placed at the proposed National Nuclear Archive than at Kew because it was designed specifically to hold them.

A. Claudel commented that we needed to consider how national organizations worked with national archives – the national archives have a clear mandate to preserve information, but are they the right or the only partners?

WHAT TO PRESERVE

SESSION 8 – MINIMUM SET OF RECORDS

37. Development of a Minimum Set of Records for Radioactive Waste Disposal

Simon Wisbey, NDA-RWMD

Background

The concept of developing a 'minimum set' of records to support long-term memory relating to radioactive waste disposal facilities was presented at the October 2011 workshop of the RK&M project. Following further thinking, the concept was included in presentations to WM2012 in Phoenix in February 2012, and again at the project meeting in Paris during April 2012.

The basic concept is based on the preparation of records explicitly for the passive management phase, stretching into the future beyond the first few hundred years. These records would be selected to be the minimum set necessary to inform the future, and would be in a common format, so that they would be recognizable and comparable from one facility to another. This would be expected to assist with the interpretation of fragmentary records. Among other things the records should signify that this is a man-made site, and that the contents can be dangerous.

At the April 2012 meeting, it was proposed that an expert group should be established to exchange and evaluate ideas, to prompt debate and seek formal review. A group of four volunteers was formed, drawn from Czech Republic, France, Sweden and the UK. The intention was to produce a preliminary output, then seek consultant support to develop the ideas for presentation to the RK&M project as part of the 'menu-driven document'.

Work has been undertaken towards the preliminary output, but finding realistic time commitment from the volunteers has proved difficult. It has been agreed that long-term records are needed to demonstrate compliance with regulatory requirements, and to help protect workers and the public (in particular by deterring human intrusion and protecting important barriers). On this basis, a preliminary set of data classes has been identified.

A related thread of investigation has also been developed on the basis that a buried repository will represent an anomaly in the environment. In the long-term future, if records were to be lost, surface-based surveys may find clues to the existence of the waste disposal site without drilling or excavation. Such clues may then point to the existence of records.

It is now important to access funding, either from the RK&M project or national programmes, to develop these strands of work.

Process

Following email exchange between the four volunteers, the scope of the work of this sub-group was agreed to include the following activities, in two stages.

Stage 1: preliminary prioritisation and justification for key records (sub-group of NEA project team)

- Why preserve information for the medium term? (100s of years)
- What information is required to meet these requirements?
- Why preserve information for the long term? (1000s of years)
- What information is required to meet these requirements?

Stage 2: development and refinement (work to be placed with contractor)

- Review and complete the list of reasons
- Review and compile the set of key information
- Compare with current records practice as a 'gap analysis'

Analysis

It appears that there are more reasons for preserving RK&M in the medium term than there are in the long term. In particular, regulators and the nuclear industry can be assumed to exist for hundreds of years, whereas it is unreasonable to invoke them for thousands of years. The reasons for preserving RK&M in the medium term fall into the following classes:

- Satisfy licence / authorisation conditions imposed by regulators
- Provide future populations with information to support alternative waste management decisions / actions by nuclear industry
- Discharge duty to protect future populations from radiation exposure
- Protect the environment from radioactive contamination

In contrast there are just two enduring classes of reason for preserving RK&M into the long term: protecting future populations and protecting the environment. In conducting this analysis it is assumed that the records are not lost, and remain legible.

A number of common information classes emerge from the analysis of information requirements. These include:

- Purpose and location of the facility
- Contents and origin
- Hazards

A number of other types of information have been identified and these will need to be further developed as part of the Stage 2 studies.

Passive indicators – future clues

A buried structure containing radioactive waste will represent an anomaly in the environment. Excavation and emplacement is likely to reduce the density of the rock volume but increase its iron content (if steel containers are used). Thus, surface-based surveys may detect gravitational, magnetic and/or resistivity signatures.

Geophysical surveys are commonly conducted using airborne detectors to cover large areas quickly. A useful response depends on host rock characteristics and the thickness of Quaternary deposits, and it is unlikely that shapes can be resolved, but low density regions will be seen as cavities, and are likely to attract attention. Simple 2D models can be constructed to test the instrumented response with today's technology.

A similar approach that does not require instrumented surveying is the concept of 'self marking' sites. Residual surface features leave scars on the landscape, and will represent visual clues to previous activity. Such features may include bund walls built to preserve visual amenity, altered water courses or access routes for road and rail. There are many examples where similar visual clues have existed for several thousands of years. With planning, it may be possible to engineer these into the design of new geological facilities.

Summary and Conclusions

Following workshop discussions, the concept of formally developing a minimum dataset for long-term records has started. The work is based on identifying reasons for retaining data, and then deriving appropriate information. Preliminary categories have been identified and the output is ready for contractor development, subject to approval of funding.

A related piece of work on passive indicators has also been developed. Experts in geophysical surveys have agreed that buried features may be detected by gravitational, magnetic or resistivity signatures. Detailed forward modelling has been planned to determine the potential for future surveys to identify a repository at depth, again subject to approval of funding.

Discussion Notes

C. Pescatore commented that 'detailed forward modelling' about human intrusion was outside of the scope of this project. The project is on how to preserve records, knowledge and memory.

It was generally agreed that this element of project work would be reconsidered in the project meeting on 14 September 2012.

HOW TO PRESERVE RK&M – PART II

SESSION 9 - PRAGMATIC ORGANISATION OF RK&M PRESERVATION: COST, FUNDING, HUMAN RESOURCES

40. RK&M Insight from the Field of Decommissioning: Survey of the NEA Working Party on Decommissioning and Dismantling

Ivan Rehak, OECD NEA

In recent months the OECD NEA Working Party on Decommissioning and Dismantling (WPDD) made a survey on Costs Associated with Loss of Records, Knowledge and Memory (RK&M) in Decommissioning, which focused on practical impacts on project development and costs stemming from unavailability of record, knowledge and memory in decommissioning projects.

In the introduction, the questionnaire gave reference definitions of terms of *Record*, *Knowledge*, and *Memory*, explained the purpose of the questionnaire which was a brief presentation and discussion at this workshop, and encouraged responders to respond with a basic level of information without a need of extensive detail.

Responders were from two professional groups – the already mentioned WPDD, which focuses on regulatory and strategic aspects of decommissioning, and the OECD NEA Co-operative Program on Decommissioning (CPD), oriented towards technical aspects of decommissioning area and being complementary to and stimulating the former one.

The questionnaire comprised three questions:

Question 1: Can you cite example(s) of decommissioning projects in which the *loss of records* [see reference definition] had an impact on ability to progress the project and on its costs? Please describe briefly.

Question 2: Can you cite example(s) of decommissioning projects in which the *loss of memory* [see reference definition] had an impact on ability to progress the project and on its costs? Please describe briefly.

Question 3: Have you encountered any decommissioning situation characterised by actual *loss of knowledge* (as per reference definition above). Did this have an impact on ability to progress the project and on its costs? Please describe briefly.

The first and the second questions had a request attached to rank how seriously the responder would consider that impact (given a choice between three ranks: marginal, significant but without blocking project, and so significant that project was gravely hindered or rendered very much more difficult). The responders were also asked to provide information on the impact on costs.

Eleven responses from 8 countries were received, including Canada, France, Finland, Germany, Japan, Republic of Korea, Sweden and the UK. Responses covered completed or ongoing decommissioning projects on multifarious facilities, such as power and research reactors, laboratories, hot cells, spent nuclear fuel storage facilities, and site remediation after the decommissioning of uranium conversion plants.

Eleven examples of decommissioning projects on loss of records were received, reporting a lack of 'as built drawings' (i.e. drawings comprising all up-to-date changes in systems & structures having been made during operation); a lack of information on material and radiological inventory of buildings, components, operational and legacy radioactive waste for removal (for both nuclear power plants and fuel cycle facilities), and a lack of information on operational history (including events) that may result in discovering an unexpected contamination. All of the rank-impact-evaluated responses (eight) referred to either marginal or significant but not project-blocking impact. Two responses reported a *trivial* impact on cost.

Nine examples of loss of memory from decommissioning projects were received, citing the retirement of operational staff, and the lack of information in operational logs. Again, all of the rank-impact-evaluated responses (six in this case) referred to either marginal or significant but not

project-blocking impact. One response reported a *marginal* impact on cost and two responses even reported that the budget overran cost figures (*10 and 30 percent*, respectively).

Finally, loss of knowledge was reported in five responses, pointing to research facilities having undergone several systems and components modifications during their operational lifetime, many of them insufficiently recorded. Difficulty with reading and interpreting old records, difficulty with knowledge transfer, poorly organised archives, and a lack of knowledge of how to retrieve already archived information were also reported.

Although the survey was basic, it showed challenges in record, knowledge and memory keeping during decommissioning.

Since proper collection and retention of data during decommissioning has to be performed even during the operation of a nuclear facility, it is a great advantage if operational personnel recognise the particular challenges posed by decommissioning and are aware that decommissioning data are different from operational data. Timely identification of the data is necessary for decommissioning planning, and costing. Preparation of radiation and conventional safety reports is vital. Since those data are, in general, up-to-date physical and radiological inventories of buildings, structures and components, the important operational data sources are 'as-built' drawings, operational records including operational events, knowledge of operational personnel and up to date information on operational waste. Since valuable data for decommissioning may be stored during operation in different places, media, and formats, centralising the data for decommissioning (including drawings and operational records) is beneficial. Updating the data for decommissioning during operation may generate additional cost, and in some countries it has become an obligation. Interviewing operational personnel, especially long-serving and retired personnel on non-recorded changes of structures and components, and operational history including non-standard events is invaluable. After operational shutdown and drainage of systems it is necessary to prepare a comprehensive radiological survey plan for decommissioning based on operational information, and to carry out the radiological survey. Physical data updating must inevitably be accompanied by a comprehensive and detailed site walk-down.

It is vital to have updated input data to prepare the decommissioning plan and to carry out decommissioning. Later change in input data during the decommissioning process may create changes in carrying out decommissioning and each change generates additional costs, which in some cases may be significant.

41. The importance of records for decommissioning and impacts from lack of records

Jean-Guy Nokhamzon, CEA

Planning for eventual decommissioning should be considered during the design and operation of a facility. By doing so, the information will be readily available and transferable when needed. The main decommissioning records include: records of the design, construction, modification, operation, and shutdown of a facility. Keeping these records will typically be the responsibility of the operator.

Need for an RMS

The preservation of the necessary information for the duration of the active post-shutdown phase, safe enclosure, and final dismantling requires the early establishment and maintenance of an RMS. An RMS is desirable to facilitate safe and efficient decommissioning.

The main goal of a Record Management System (RMS) is to provide necessary, sufficient, and up to date information for those who perform the decommissioning and for other parties to make informed decisions with regard to the planning and implementation of decommissioning actions. *There will be significant financial consequences if there is inadequate documentation to support decommissioning*.

Good practices

Throughout the life of a facility the records archive should be frequently and independently audited, with decommissioning as a primary focus.

An auditing process should be aimed at identifying gaps in an RMS and addressing the usefulness of the archives for decommissioning.

Since technologies may change and knowledge of a facility may diminish, information may become less understood over time. It is therefore important that the information transferred to the future users be usable. Keeping control of records (and institutional knowledge) is necessary for the whole decommissioning process.

Redundancy and diversity in an RMS are necessary for the effective management of the records.

The media used need to be selected to ensure the durability, readability and retrievability of the information they contain.

Impact on decommissioning planning and implementation from lack of initial information

Although requirements for operational record-keeping are presently well established and implemented at nuclear facilities, the experience with older, shut-down facilities is different. The French Atomic Energy Commission (CEA) has carried out a variety of decommissioning projects for several reactors and nuclear facilities throughout its centers in France. Such projects have included 15 reactors and 11 facilities (research laboratories and fuel cycle's facilities). All decommissioning projects were faced, more or less, with a lack of accurate and faithful record. These facilities were constructed and operated well before current record-keeping requirements for safety (and eventual decommissioning) were promulgated. Typically, this causes the following situations to arise:

- The contaminated areas are isolated for over several years prior to any decommissioning project appearing. The personnel who worked at the facility have retired and important records and institutional knowledge for the decommissioning planning are no longer available.

- No information on operational incidents, radiological surveys or material inventories was maintained during the operating life of the facility for use in its eventual decommissioning. No drawings, design information ("as built"), photographs or other records that reflected the as-built and as-modified conditions of the facility are available.

The start of the D&D project can be affected significantly by this lack of information and data.

As an example, in one project,

- Although some spills of radioactive material occurred over the operating life of the facility and residual contamination remained, no records of such events were available. In addition, the inventory of spent sealed sources was neither accurate nor exhaustive. The decommissioning team was faced with a lack of current, accurate and reliable records.
- Over 25% of the duration of the total project had to be devoted to reconstructing a minimal amount of critical information to analyze the possible D&D strategies and prepare a decommissioning plan.
- New surveys of the contamination of the facility and dose rate surveys, or the study of the construction characteristics of contaminated areas, become necessary. All of these operations lead to additional, unnecessary exposure of the D&D personnel, which is not in keeping with the principle of minimization of radiation doses.

Lack of records and reliable information can present the implementer with huge problems (safety, security, waste…) during the decommissioning process and can have an enormous impact on projects' schedules and costs. The project can last many more years than initially planned and costs

can grow to twice or three times their initial estimate. In fact, "availability of records and knowledge" should be dealt with as an important variable affecting costs.

42. Passive Institutional Controls for WIPP – Estimated Financial Costs

Russ Patterson, Department of Energy, Carlsbad Field Office

Thomas Klein, URS Regulatory & Environmental Services

Abraham Van Luik, Department of Energy, Carlsbad Field Office

The Department of Energy/Carlsbad Field Office (DOE/CBFO) is responsible for managing all activities related to the disposal of defense-related Transuranic (TRU) and TRU-mixed waste in the geologic repository, 2150 feet (650 m) below the land surface, at the Waste Isolation Pilot Plant (WIPP), near Carlsbad, New Mexico. The main function of the Passive Institutional Controls (PIC's) program is to inform future generations of the long-lived radioactive wastes buried beneath their feet in the desert. For the first 100 years after cessation of disposal operations, after the rooms are closed and the shafts leading underground sealed, WIPP is mandated by law to institute Active Institutional Controls (AIC's) with fences, gates, and guards on patrol. At the time of last recertification/closure a final plan must be in place setting out how to warn/inform the future after the AICs are gone, and the consequences of intrusion into the geologic repository disposal area. A plan was put in place during the 1990's with records management and storage, awareness triggers, conceptual permanent marker design and testing schedules. This work included the thoughts of expert panels and individuals. The work held up under peer review and met the licensing criteria of the U.S. Environmental Protection Agency (EPA).

As part of the PIC's program developed for the WIPP licensing process in the 1990's, financial costs of the program were estimated. The PIC's program was divided into three major areas, with the level of detail, and surety of associated costs varying for each area. The most detailed plans, and subsequently the most refined cost estimates, were prepared for the area of permanent markers, in which detailed schedules for testing, constructing/fabricating, and emplacing were developed. Records management and Awareness Triggers were considered; but mostly "rough" estimates were developed with "ball park" numbers used for large sections of work. As work in this area has progressed, cost estimates have been developed for specific portions of the planned PIC's work scope as recently as 2007; but once again mostly in the Permanent Markers area.

The PIC's program, developed and costed during the 1990's, met the regulatory requirements of a system designed to warn/inform future generations that a nuclear waste repository lies beneath the south-eastern New Mexico desert and this system is technically feasible to implement. However, it may not be the most practicable program. DOE is presently in the process of reviewing and reconsidering all facets of the PIC's program certified by EPA in 1998, in an attempt to optimize the present plan and develop the most practicable PIC system at a reasonable cost. This optimization should take into account, for example, the ethical question of deciding what level of financial investment current generations ought to make to warn future generations of potential dangers. The development of such an ethical balance is an international issue that will benefit from being addressed by the RK&M expert panel. DOE is participating in the RK&M project workshop(s) to assist in the development of an international consensus statement regarding PIC's that will provide suggested guidance for consideration by national radioactive waste disposal programs. DOE will use this international guidance, plus other available information, to further refine, revise, and defend the future WIPP PIC's program.

In the presentation for the Nuclear Energy Agency (NEA) "Preservation of Records, Knowledge and Memory (RK&M) Across Generations" 2nd Workshop, an overview of the WIPP PIC's financial cost estimates will be provided, including the categorization/structure of the estimates (examples will be shown); along with DOE's confidence in the cost estimates; and a discussion of potential funding issues and possible avenues to address these issues.

Discussion Notes

In response to M. Jensen's question, R. Patterson agreed that the costs drew on the the original WIPP markers study, and added that this was virtually the only serious source. The DOE is currently reevaluating the programme, but this shows what costs have been estimated.

A. Rose asked if the DOE would be organising a workshop similar to the one it had held at the beginning of the PICs programme as part of the re-evaluation process.

R. Patterson said that they were waiting for input from the RK&M project, but will probably have additional workshops and peer reviews and we will need to involve EPA into the process, so that the current, legally defined proposal can effectively be alternated if need be.

J-N. Dumont questioned whether the removal of roads and electricity lines et al. were part of RK&M, suggesting they should be considered as part of decommissioning instead.

43. ANDRA Memory Programme: Costs and funding

Jean Noël Dumont

Considering possible means for RK&M preservation leads to the question: "*how will this be funded?*", which in return leads to the question "*how much will it cost?*" The issue of funding seems therefore to be addressed after the issue of costs, but in fact they are strongly linked and have to be treated in parallel.

Assessing RK&M expenses
When assessing the economic viability of a project, two basic elements have to be considered: the date and the nature of the costs and benefits.

The date of expense
Expenses occurring now and expenses occurring in the future have to be considered differently for two reasons: the discount of future expenses and the uncertainties on their estimate. An amount of 100 € spent in 10 years has not the same value as the same amount to be spent now, as it can be covered by the benefits, over these 10 years, of investments made now. If we assume two projects with perfectly known future costs and benefits, their profitability is compared by converting the costs and benefits occurring at various dates into costs and benefits at present date, through the use of a discount rate, then summing them to calculate the net present value (NPV) of the projects. The choice of the discount rate is thus a decisive issue.

Furthermore, future costs and benefits are not perfectly known. They are affected by risks, uncertainties and opportunities, which grow with time distance. In the case of RK&M preservation, at time distances of 10 years or less, which are considered in the project glossary as "very short term", we may find expenses already decided (uncertainty on the occurrence of the expense equals zero), but with risks and uncertainties on the amount. This is the case, for example, for the Historical Archive Center in France, which has been decided, but the implementation of which is subject to uncertainties. Two options are envisioned: either construct a specific building or search for a heritage building, which would then be restored and arranged. The former option is more easily manageable; the latter provides more value with regard to memory preservation.

The nature of the costs
Some expenses are supported once (investment costs), whereas others are repeated continuously or periodically (recurrent costs). In the case of memory preservation, investment costs refer to the implementation of passive devices, for example the building of markers, whereas recurrent costs refer to the "active" part of the dual track strategy. The specificity of the memory preservation issue is that no limitation of time is given to these recurrent costs.

Taking again the example of the Historical Archive Center in France, an investment budget has been estimated, corresponding to the cost of construction and equipment. This expenditure will be

distributed over a few years. Recurrent costs will be also supported: operating costs, estimated as 15 % of the investment cost, each year; specific supplies; maintenance costs, estimated as 50% of the investment cost, every 30 years. This does not include staff costs, which are estimated to be 4 people, on the basis of Full Time Equivalent.

Other factors to be considered
Two other factors are also to be kept in mind: the weight of taxes and the way manpower costs are calculated. Taxes may represent a significant part of the costs of a project. They are not intrinsic costs, but result from political decisions at national and local levels. The cost of manpower depends also on political decisions, at national level (payroll) and at the level of the implementer, through the way overheads are distributed over the activities.

Funding RK&M expenses
When reflecting on funding, the timescale is also of utmost importance.

Before repository closure
Before repository closure, it may be considered that expenses related to RK&M preservation are part of the waste disposal expenses, and covered through the same means. It should be noted also that the existence of the repository may encourage some activities which bring their own funding while contributing to memory preservation. For example, environmental observation around the repository may create scientific research activities on environment and climate change.

After repository closure
After repository closure, funding of RK&M preservation costs may be provided by three different sources:

- Some activities contributing to RK&M preservation may generate revenue: tourism, museum visits, scientific research etc.
- Activities may be subsidized or sponsored, by public or private organisms, in the same way as restoration of heritage monuments may be subsidized or sponsored;
- Benefits from a dedicated fund may be used, in the same way as the expenses related to the Nobel Prizes are funded by the benefits of the assets managed by the Nobel Foundation.

In all cases, the durability of financing derives from the durability of the high value associated with RK&M preservation activities. An important objective of international research on RK&M preservation in the medium term should thus be to propose RK&M related activities which may keep a high positive value for a long period of time.

For the specific case of a dedicated fund, many lessons may be learned from the experience of the Nobel Foundation, which has been distributing the Nobel Prizes for more than a century (1901), despite two world wars and the great 1929 economic crisis.

Lessons from the Nobel Foundation[22]
According to Alfred Nobel's will, most of his estate at the date of his death, more than SEK 31 million (today approximately SEK 1,702 million, or approximately 200 million €) should be converted into a fund and invested in "safe securities". The income from the investments was to be 'distributed annually in the form of prizes to those who during the preceding year have conferred the greatest benefit to mankind". The invested capital at market value per December 31, 2011 amounted to SEK 2,973 million (approx. 350 million €).
The governance of the Foundation, namely the investment policy, is of paramount importance to the preservation and, if possible the augmentation of the funds and, thus, of the prize amount. This may be illustrated by two facts:

[22] Most information presented here comes from the official website of the Nobel Foundation, namely the webpage: http://www.nobelprize.org/nobel_organizations/nobelfoundation/finan-manag.html.

- in the early 1950s, the Foundation's Board of Directors obtained permission to invest not only in real estate, bonds and secured loans ('safe securities" according to the spirit of the original investment rules), but also in most types of stocks. With this freedom to invest, along with the long-fought-for-tax-exemption granted in 1946, the prize amounts, which had declined steadily from 1901, increased. The real value of the prize amount was restored in 1991. It reached SEK 10.0 million in 2001.

- in order to preserve the value of the fund on the long-term, the Board has defined a financial rule, which states that expenditure ratio (calculated as the total amount for all Nobel prizes and operating expenses as a percentage of the market value of the Foundation's equity on January 1) should be at the 3-4 percent level. The ratio in 2011 was 3.8 percent, as in 2010, but in 2012, noting that in the recent years, these expenses have exceeded the average return on the foundation's investments, the Board decided to reduce the prize amount by 20 %.

The governance of the Foundation is continuously updated: an International Advisory Board and a decision-making Investment Committee were established in 2011.
Over the years, the Foundation introduced new activities in the spirit of Alfred Nobel's will: Nobel Museum, Nobel Peace center, etc.

Development of a dedicated fund
In the same way as the fortune, converted into a fund now managed by the Nobel Foundation, was constituted during the life of Alfred Nobel, a specific fund dedicated to post-closure activities could be constituted during the operating phase of the repository. During this period, the benefits would be fully reinvested. Specific investment rules could be defined, related to the aim of the fund – to promote memory activities in the long term.
As an example, if we assume an annual fee of 1 M€, an operating phase lasting 100 years and a constant benefits ratio of 3 % over this period, the value of the fund at the end of the operational phase would be 627 M€.
After the repository closure, the fund would provide financing according to the average benefits rate of the moment. For example, if the benefit rate remains the same as during the operational phase (assumption 3 % as above), the available funding would be approximately 20 M€/year. However, many economists recommend lower discount rates in the distant future, due to uncertainties; therefore assuming a benefits rate of 1 % seems more reasonable, which would yield 6,3 M€/year.

Conclusion
The issues of costs and funding of expenses related to RK&M preservation in the short and medium term are not only strongly connected, but also show similarities. Both are subject to risks and uncertainties, increasing with time. Both demonstrate the importance of providing a positive value to RK&M preservation activities, which may reduce costs and raise motivation for funding. In both cases, governance and political aspects play an important role. Finally, examples presented in this paper are treated at a national level, but extending this approach at international level would probably be beneficial.
The pre-operational and operational phases of RWM repositories are a privileged period for progressing on the issue of RK&M preservation features; devices may be implemented and funded as part of the disposal expenses, and the funding for post-closure activities may be prepared. The relevance of RK&M features, both active and passive according to the dual-track strategy, and of the associated funding may also be reviewed on a regular basis (e.g. every 10 years). This could foreshadow the governance to set up after repository closure.

Discussion Notes

In response to a query from A. Claudel, J-N, Dumont said that RK&M costs were included in operation and development costs of the waste repository. The problem was one of guaranteeing the durability of that funding.

J. Schröder commented that in Belgium, there exists a "Long Term Fund" for financing technical issues, whilst the "Middle Term Fund" was created to finance social costs. With regard to the low and intermediate level waste repository project, the Middle Term Fund is used to finance a "Local Fund",

which is meant to last for at least the duration of the repository and is to be invested in local projects, thus contributing to living memory.

C. Pescatore remarked that RK&M should not be seen in isolation from other aspects of oversight, and added that this notion of oversight needs further elaboration and should be taken up in the glossary.

44. Summary of Day Two

Regulation cannot be seen as the only solution to the problem – especially if regulation stops at the simple requirement to 'keep any relevant records'.

There exist many independent mechanisms for environmental monitoring, memory preservation and archiving that RK&M programmes may be able to use. RK&M preservation programmes for radioactive waste need not be developed in isolation from other programmes for preservation of information and environmental monitoring. These are exemplified by the IAEA INIS, the NEA Databank and the UNESCO Memory of the World Programme – and further mechanisms are being analysed in the study on Supranational Mechanisms to support RK&M over the medium term.

Existing mechanisms for memory preservation such as the UNESCO World Heritage Register show that official recognition of the societal value of a place or object is a powerful way to create a wider and more enduring respect and interest in that place or object. **Access to information about a place or object increases the value in which it is held.** This access to information must be proactively created.

It should be noted that the success of RK&M preservation cannot be judged by whether they last for one thousand or ten thousand years – the success is in whether the attempt establishes the need and responsibility in the minds of regulators, operators, stakeholders and the general public, and whether that need and responsibility is understood and passed on to the next generation.

Concepts such as the 'sacrificial layer' and "regeneration" (as developed by the Long Now Foundation and the ANDRA Memory Project) are useful in understanding how people develop and change their heritage. These concepts can help us understand how the creation of a point of engagement – such as a monument or a ritual – need not be created to withstand a changing environment, like the repository, but should be expected and designed to engage with the 'rolling now' as its means of survival. The DoE's Legacy Management programme brings together many of these ideas - cultural memory, reinvention, constant engagement with the present.

Current archiving requirements are very general – asking, for instance, for 'all relevant information'. Also, there is a preference for analogue material. The necessity to keep archives in more than one location is mentioned in legislation, but rarely put into practice as of yet. It was questioned whether National Archives are, in fact, the best place to preserve nuclear records. There may be benefits in having a specialised National Nuclear Achieve, as proposed by the UK.

Technical developments in this area – such as the 'Sapphire Disks' – should be noted, especially the fact that their development identified the same principles of **durability, readability and retrievability** in the CEA presentation as good practice for record keeping in decommissioning.

The principles of durability, readability and retrievability will be important to the development of the Minimum Set of Records. This work area has identified that a Minimum Set of Records would be a useful tool in the medium term, and that there needs to be a prioritisation and justification of key records.

The PIC programme of WIPP and the decommissioning experience provide useful models to begin thinking about how to identify the issues of costs and pragmatic organization of RK&M preservation. In any event the concept should be "practicable". The WPDD survey and the CEA presentation identified that a key point for RK&M loss was at the transfer from operation to decommissioning, because operational data was collected without thought to how the data needs would be different for a site undergoing decommissioning, and stated that, *'There will be significant financial consequences if there is inadequate documentation to support decommissioning'*. In this context, there may be lessons to be learnt from the Asse II Mine situation.

The ANDRA Memory Programme bases the assessment of costs with the *date* and *nature* of the cost. There could also be created sources of revenue, such as museum visits or scientific research. It may be necessary to develop a dedicated fund for RK&M, building on lessons learnt from the Nobel Foundation.

45. Reflection on the Workshop

Mikael Jensen, Consultant

A. Introduction

My impressions
Looking back on the meeting I was

- ***impressed by*** the broadened interest and large attendance
- ***captivated by*** intriguing reasoning, while also
- ***looking for robust solutions***, and
- ***reassured by*** practical examples and experiences.

I was also impressed by the openness of the organizers in inviting Cécile Massart and to use the meeting room as an exhibition for her artwork.

Our task is important
As a 2005 survey in two Swedish municipalities showed, a significant portion of people thought that the time perspective for safety should carry on in a million year scale implying that, according to the stakeholders, information could be of value over the same time span. In any case there is no question that the subject is considered important, particularly by stakeholders.

On the matter of structure, I have had to squeeze all my impressions into a few categories, unfair to some presentations for several reasons. Most of the presentations cover more than one category.

B. Framing the issue

A number of presentations were made that all help to frame the issue.

Let us not forget that the most important definition of our goal has been defined by the Draft Collective statement from 2010;

> RK&M …must be taken into account in implementing national radioactive waste disposal programmes[23] in order to:
>
> - maintain confidence in the safety and security of the system by allowing for accurate and reliable review by the authorities and providing for visible and transparent oversight of disposal projects across time
> - address concerns and answer requests from the public, especially local communities
> - ensure that future generations can base their decision making for radioactive waste disposals on relevant and pertinent data
> - promote awareness of past activities.

I have earlier been occupied with what is called endless speculation, in connection with human intrusion studies, to such a degree that I cannot hide my satisfaction with the above bullets. They leave little room for such guesswork. Clearly, we now stand on stable grounds. What we need is to "formulate RK&M preservation methods and processes" and "ensure robustness" to add a few more quotes from this excellent draft.

[23] The final collective statement is available and is on line http://www.oecd-nea.org/rwm/rkm/documents/rkm-collective-statement-en.pdf.

Regulatory requirements
The work on the regulator requirements presented by Helen Gordon- Smith, shows that there is little regulatory guidance in place.

Perhaps this has been a reaction to the early days where the US DOE were expected to "predict" or "project" (the risk of intrusion into the Waste Isolation Pilot Plant, WIPP) and the subsequent critique by the US National Academy of Sciences[24].

However, as correct as that criticism now appears - of the feasibility of scientific supportable prediction related to institutional control, and hence of its presence in regulations – there is a lot that can be done in the area of RK&M that perhaps follow common sense rather than scientific prediction over millennia. We must still do our best, recalling ICRP's practical interpretation of the optimization concept: "Have I done all I reasonably can to reduce doses?"

Clearly this is a question for us all, and it includes the regulator who might do well to inform at an early stage how that goal is achieved in the regulator's view.

If there is no national guidance available on RK&M, the local community may feel the need to formulate their own strategy, which I believe would be an undue burden to place on local decision makers. I also note that decisions on local, regional and national levels will benefit from an international reference position such as one given by the NEA.

Relation between RK&M and safety
The surveys of, for instance, the NEA's Integration group for the safety case, IGSC, show that RK&M project is looking at the issue from every possible angle. I believe the activities related to the safety case evolve and that RK&M has bearing on the later stages in mature programmes. It has a central place on what we now call the "safety story".

Monitoring
Both geological and environmental monitoring often plays a role in the stakeholder dialogue. To the extent that monitoring has the potential to contradict the safety case, it can be seen as compensating for lack of confidence in safety. This brings to mind monitored retrievable storage - in some peoples view requiring monitoring for thousands of years. The issue of monitoring thus contains many challenges. In such cases, an important part of the "solution" lies in a clear analysis of the goal, which may single out the different reasons behind different kinds of monitoring.

Environmental monitoring occurs with a number of different objectives, and some general monitoring activities in society may be used to offer information of areas near geological repositories.

"Standing" issues in monitoring
The local community's role is defined by the proximity - in space – to a planned repository and those responsible for its development. The local community is most often also thought to be a group well positioned to express possible or imagined concerns from individuals from society in a distant future, i.e. they are considered to have standing (in Latin, "locus standi") in the process, whether within a formal legal process or not.

This creates a link between two very different issues, i) immediate health and safety concerns for present individuals in a local community and ii) complex evaluation of a safety analysis over many millennia. Monitoring may be referred to by stakeholders in both of these compartments.

In any case, the process of monitoring will generate records, part of the process of RK&M.

Safeguards
It was pointed out by Claudio Pescatore that there was very little input from IAEA regarding the role that safeguards might have regarding RK&M. One problem may be shared with RK&M in general, i.e. that the issue – post closure safeguards - is somewhat premature. Observe, however, that Safeguard results, although not publicly available, may have a role in the long run. Information which is a

[24] From the National Academy of Sciences' (NAS) congressional mandate for the project, reported in "Scientific Bases for Yucca Mountain Standards, 1995": "…(C) whether it is possible to make scientifically supportable predictions of the probability that the repository's engineered or geologic barriers will be breached as a result of human intrusion over a period of 10,000 years". The energy policy act 1992, SEC. 801. Nuclear Waste Disposal.

hundred years old, or more, may not have to be kept secret. It should also be noted that in fact, through the IAEA inspections, safeguards can be seen as another type of existing monitoring.

A "safety" analysis of RK&M

Uncertainty analysis
This important topic deserves a better treatment than the author can squeeze into this summary. In the terminology of the safety analysis, we could call this a discussion of the uncertainties in the safety analysis (of RK&M), involving the loss - and recovery - of information and being aware of overconfidence. The presentations of Abe van Luik on tsunami warning stones show that when memory can be passed on through communities it can last for around 1000 years, but also that warnings are often not taken seriously.

Another solution suggested by Prof. Wolfgang Ernst points to the possibility of a message based on radioactive decay, bringing to mind the repository content's capability for self-referencing or self-marking. Another version of this was discussed regarding the self-marking capacities of other physical properties gravitational magnetic self-marking. The link to the future also includes artefact recognition which was discussed by Prof. Cornelius Holtorf. Knowledge of our ability to recognize artefacts may serve us well in the both the uncertainty analysis and the solution that must eventually be constructed.

Critique of the distant future as a steering mechanism
Let me add a reflection I voiced during the workshop, perhaps without the clarity the subject deserves. We sometime discuss how the distant future might look, in order to design our transfer method. In this design process we will be faced with alternatives. In my view, for any possible distant future that will seem to favour one alternative design over another, say A over B, I suggest that it is possible to find another distant future that will compel you to favour B over A. (The same will apply for human action on repository sites, a subject outside this project's mandate. It is, by the logic above, not even possible to recommend staying away from geological resources, although such recommendation may flow from arguments in the next section).

If that is the case, why not concentrate on what we do in other societal planning, i.e. assume, like the philosopher Hume, that tomorrow will be like today in many ways (the Sun will rise tomorrow). Following that line of reasoning, we can also argue that the assumed future society is coherent; it could exist in the future because that is what it does today. This viewpoint does not answer all questions but at least it is open to the application of current moral, legal (etc.) reasoning.

What we must do
Disregarding attempts to make proofs over the long term does not diminish our duty to carry out the task as well as we can, recalling the ICRP quote above. For this reason we may have to revisit the presentation of the professors Ernst and Holtorf. The translation process (from their advice to us understanding all of it) may be complicated, but if we don't take their advice we cannot claim to have done "all we reasonably can".

C. Experiences leading us forward

Nuclear archives
Existing experiences on nuclear archiving reported by Simon Tucker, John Day and J.P Boyazis will give us perhaps the most valuable lessons since the activities involved relate to real experience rather than assumptions in theoretical discussions. For instance, medium term nuclear archives will need to keep a records management system alive over a relatively long time and the lessons learned in the process will be unique. IAEA's very large International Nuclear Information System, INIS, also belongs to this group.

Parallel archive experiences
The UNESCO archive presented was interesting in several ways, through i) the popular support it enjoys, an important factor in its prognosis, ii) the international aspect and iii) through its potential for inclusion of information about a future waste repository.

D. Archive construction

The Minimum information set of records
It may be premature to discuss archives in detail before the goal, function and form is decided, but these discussions cannot be completely separated. It is exactly in the definition of the minimum set or records that new items emerge which will add to the understanding of the archives' form and function.

It is not as if waste disposal archives have not been discussed at all. It can be understood in two dimensions:

> i) the minimum set of record in a national archive, understood to constitute the most informative body of information, or
> ii) the minimum set of records that will give a good understanding of a repository.

The different notions are described (or perhaps more appropriate: speculated about) in IAEA-TECDOC-1097, Maintenance of records for radioactive waste disposal (1999). A form of minimum set of records is described, relating to a reduction necessary to fit an archive into an international framework:

> "The top level of the hierarchical structure is a high level information set (HLI) which consists of even more condensed information. The HLI would give sufficient information to provide a fundamental understanding of the repository system. The HLI has to meet the needs for future generations. The HLI would be placed on a national and perhaps also if decided by national authorities on an international level. A more detailed discussion of the content of an HLI is in Section 4."

The development of this document and others were influenced by Torsten Eng and me offering our experiences from the Nordic Study[25].

The Nordic study did not however go beyond a general description of the goal of the different archive functions. As programmes are maturing, it is now necessary to address the archive needs in a much more concrete way (while keeping in mind on a parallel track that a formal framework, formal legal requirements etc., would make things a lot easier).

Supranational mechanisms
Inter- or supranational mechanisms are highly relevant in such a specialized topic as RK&M. I don't think I have come across any area of research as international as this. It was pointed out that interested members of society may contribute to the archive's wellbeing and survival. The large scale nuclear stress tests all over the world after the Fukushima accident show that the society, national and international, expects global feedback from all individual nuclear experiences.

Also, the international aspect may be a crucial factor in the credibility of an archive's longevity. The international aspect is therefore not merely a collection of experiences and ideas, but a central part of the goal and function.

As pointed out in a previous workshop, the Aarhus Convention (The Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters) requires information to be available, making information service an important function in the archive's prognosis.

When the clock strikes…
The Long Now foundation's 10 ka clock undertaking is of special interest for several reasons, the first being that is it outside the nuclear realm. It is an experiment, or experience, of the same type as the deep space exploration vessels – a subject area in which the foundation also has made contributions - whose continued performance over many thousands of years we take for granted without proof, more readily than for deep geological disposal systems. I can speculate that in the future of the discussion on the clock's function and (deeper) purpose, arguments will be of interest for RK&M. We may also ask for whom the clock strikes (or the bells tolls). The benefit of this process is open to an

25 Informing Future Societies about Nuclear Waste Repositories, Final Report of the Nordic Nuclear Safety Research Project KAN-1.3, NKS 1993:596 (1993).

interesting debate. The radiation protection benefit is perhaps a more obvious driving force for activities in connection with a nuclear repository (not that we claim to know much about individuals in the distant future). Perhaps one may come to a point where long term processes become more common and accepted.

The sapphire discs
ANDRA's sapphire discs are part of a number of approaches where paper is replaced by more durable materials. It is made to stimulate reflections on memory preservation. One question might be whether or not the national archives (or other relevant bodies) will accept custodianship for these materials. How will the custodians react to the introduction of a novel object in their collection? Will they require all the standardizing work on paper to redone on this this new material? Is there a risk that such records are given less attention by archivists, because of their unusual nature?

Cost and cost-effectiveness
Russ Patterson and others asked questions about cost such as

> How does the program identify and structure cost elements?
> What is your confidence in these cost estimations?

For mature programmes, discussions must sooner or later be replaced by decisions, and the cost must be recognized. This is a highly relevant question but it must be recognized that traditional cost-benefit estimates involving very small doses provided to a limited number of people will not suggest a large budget. Therefore, the stakeholder input will probably be more important.

During the time I worked on the Nordic study, I was able to follow the WIPP marker study in the US. I found many ideas thought-provoking and I believe that after the study a catalogue was produced of what people might think about markers. One group, working on how future societies may look, came up with the idea of extreme scenarios called zero probability scenarios. They were not intended to be practically relevant but to provoke ideas to describe the special type of reasoning required in the process. A space ship in the distant future is forced to crash-land and sees a large uninhabited place (the disposal site), chooses to land causing a crater with loss of integrity of the repository's barriers. Such a scenario can explain why one protective strategy (avoiding the site) may result in loss of protection, in much the same way as I indicated above in my critique of the distant future as a steering mechanism.

I have taken the whole marker study as such an example with zero or very modest practical relevance, and now I find to my astonishment that it seems to have been taken out of the deep freeze, seemingly valid in some sense, and unchanged. For the continued process, I feel that the regulators have a very large responsibility here.

In any case I believe that cost effectiveness can be of canonical value, but it is not so much the number exercise I believe in. Rather it is the fact that the analysis will point to several, completely different input characteristics, and let them be displayed for all to see. It is necessary to unfold this complexity, made up by a mixture of science and policy decisions.

E. The archive

NEA's archiving activities on RK&M is starting to constitute an international archival reference in its own right, outweighing most national efforts. Asking and answering questions like "what information should be kept and how", while still limited to RK&M, the work of the NEA starts to lay the foundation of an international archive.

Assuming national archiving will follow national legal systems, a national archive is a more strategic entity for the reasons mention above. There have been many alternatives suggested for an international archive:

A Waste Convention archive
An archive based on the reports of the so called Waste Convention (formally The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management). The IAEA is not the formal "owner" of the Convention, but supply the secretariat and the content of the Convention refers to IAEA's standards. IAEA is therefore the natural choice for such an archive.

An archive for all hazardous waste

It has been suggested that an archive might be created, based on geographical information about land areas with dangerous properties. While it is easy to see good intentions behind such a suggestion, it may prove to be too slow-moving a project since it involves an enormous amount of information. It may be a case of the best becoming the enemy of the good.

NEA as an archive custodian
NEA is strategically placed to host an archive; if the content is limited to records and information from geological repositories, the NEA is probably the best choice.

Other suggestions
There have been a (large) number of suggestions other than the ones reviewed above. To mention one, the Vatican has been named as a candidate, because of the longevity of its traditions.

The solution
Given the modest steps taken so far towards a concrete solution, and the different goals for the archive discussed, only one pragmatic solution remains: let the best archive win!

This means simply that the various contestants will have to compete. If one archive manages to establish itself it will have an advantage and also become a likely candidate for expansion into other areas as well. May the best archive win!

Appendix: Participants List

Belgium
Jean-Paul BOYAZIS - ONDRAF/NIRAS
Hugo CEULEMANS - MONA
Cécile MASSART – Artist, Consultant
Jantine SCHRÖDER - SCK•CEN

Canada
Richard FERCH - Consultant
Lisa LANG - NWMO

Czech Republic
Miroslav KUCERKA - RAWRA
Lumir NACHMILNER - Consultant

Finland
Kai HAMALAINEN - STUK

France
Luis APARICIO - ANDRA
Patrick CHARTON - ANDRA
Jean-Noël DUMONT - ANDRA
Guillaume MARTIN - ANDRA
Anastasia ILINE - Service interministériel des archives de France
Alain REY - Arnano
Thierry SCHNEIDER - CEPN

Germany
Thomas BEUTH - GRS
Stephan HOTZEL - GRS
Wolfgang ERNST - Humboldt-Universität zu Berlin
Mareike RÜFFER - The Federal Office for Radiation Protection

Hungary
Zoltan NAGY - PURAM

Spain
Meritxell MARTELL –Merience Strategic Thinking
Lumir NACHMILNER - Consultant

Sweden
Anders HÖGBERG - School of Cultural Sciences
Cornelius HOLTORF - School of Cultural Sciences
Mikael JENSEN – Consultant
Thomas KAISERFELD - Lund University
Erik SETZMAN - SKB
Sofie TUNBRANT – SKB

Switzerland
Marcos BUSER - Institut für nachhaltige
Anne CLAUDEL - Nagra

United Kingdom
John A. DAY - Sellafield
Simon WISBEY - NDA

United States
Russ PATTERSON - DOE, Office of Environmental Management
Abe VAN LUIK - DOE, Office of Environmental Management
David SHAFER - DOE, Office of Environmental Management
Alexander ROSE – The Long Now Foundation

International Atomic Energy Agency (IAEA)
Peter ORMAI - Waste Disposal Specialist

UN Educational Scientific and Cultural Organization (UNESCO)
Maria LIOULIOU - Memory of the World
Joie SPRINGER - Memory of the World

OECD NEA
Helen GORDON-SMITH - RPRWM Division
Ian HILL - Databank
Gloria KWONG - RWM Specialist
Claire MAYS – Consultant, RPRWM Division
Claudio PESCATORE - Principal Administrator
Michael SIEMANN - Head, RPRWM Division