NUMO
原子力発電環境整備機構

NUMO-TR-10-07

RMS2010

Requirements Management Systems (RMS): Status and Recent Developments

Information Exchange Meeting Report

March 2011

Nuclear Waste Management Organization of Japan (NUMO)

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1 Introduction

In recent years NUMO has been going through an intense phase of developing it own tailored requirements management system (RMS) as it was identified that:

- Requirements management (RM) is a central part of ensuring safety as part of the disposal programme,
- RM provides measures to meet the various requirements from the stakeholders involved. Furthermore, it aids confidence building,
- As the disposal programme continues over a period of more than 100 years and the constraints and premises are likely to change within this timeframe, RM should be a continuous process with a clear long-term scope.

A discussion with - and receiving feedback from - other implementing organizations, that are also in the process of developing RMS, was deemed extremely valuable. As part of the NUMO-Nagra collaboration, an international information exchange meeting was organized on 26 January 2010 in Tokyo. Objectives are to introduce the RMS as considered by the different organizations in terms of:

- Objectives and expectations,
- Status of developments and progress,
- Practical experience with the application,
- Identification of the key common features, differences, if any, and reason,
- Identification future common needs.

Representatives of implementers, at the forefront of RMS development, as well as consultants, research organizations and academics contributed to the information exchange meeting. The list of presenters is shown below:

NUMO	Tomio Kawata, Hiroyuki Tsuchi, Hiroyoshi Ueda,
POSIVA	Tiina Jalonen
SKB	Lena Morén
ONDRAF/NIRAS	William Wacquier
Nagra	Piet Zuidema
University of Tokai	Toshiaki Ohe
Parsons Brinckerhoff	Henry O' Grady
JAEA	Kazumasa Hioki

The outcomes of this information exchange meeting are reflected in this report. In Chapter 2 to 4, an overview of the discussions during the open session is given.

In the appendices the agenda of the workshop (Appendix 1), the list of participants (Appendix 2) and the presentations of the open session (Appendix 3) are included.

2 Session 1: Introduction and Overview (Chair: K. Ishiguro)

2.1 Welcome and opening remarks

(NUMO – T. Kawata)

Dr. Kawata extended a very warm welcome to the more than 50 participants to the information exchange meeting from over the world and representatives of the main Japanese organizations. RM has been initiated at NUMO not only for internal reasons but also as a tool to communicate with the stakeholders in a complex project, such as the geological disposal of radioactive waste, and demonstrate that their requirements have been met. Two years ago, a similar tri-lateral workshop was organized by SKB, Nagra and NUMO and took place in Sweden. It was followed a year later by another workshop among ONDRAF/NIRAS, NUMO and Nagra in Belgium. This time, NUMO is very happy to organize the current information exchange meeting, which will provide an update on the developments, enable the receipt of feedback and, finally, highlight the open issues to be addressed in the future developments. NUMO looks forward to constructive and fruitful discussions during this day.

2.1.1 The management of geological disposal programme of Japan

(NUMO – T. Kawata)

On overview of the evolution of the Japanese HLW disposal programme is given (Appendix 3). The start of the repository operation is estimated between 2030 and 2040. The disposal concept is similar to many European concepts. The stepwise implementation approach with the three stages of the site selection process is shown in Figure 1. Following the Literature Survey for the volunteer sites and confirmation that they satisfy the site selection factors published by NUMO, the approach consists of the three stages: PIA (preliminary investigation areas), DIA (detailed investigation areas) and finally the RS stage (repository site).

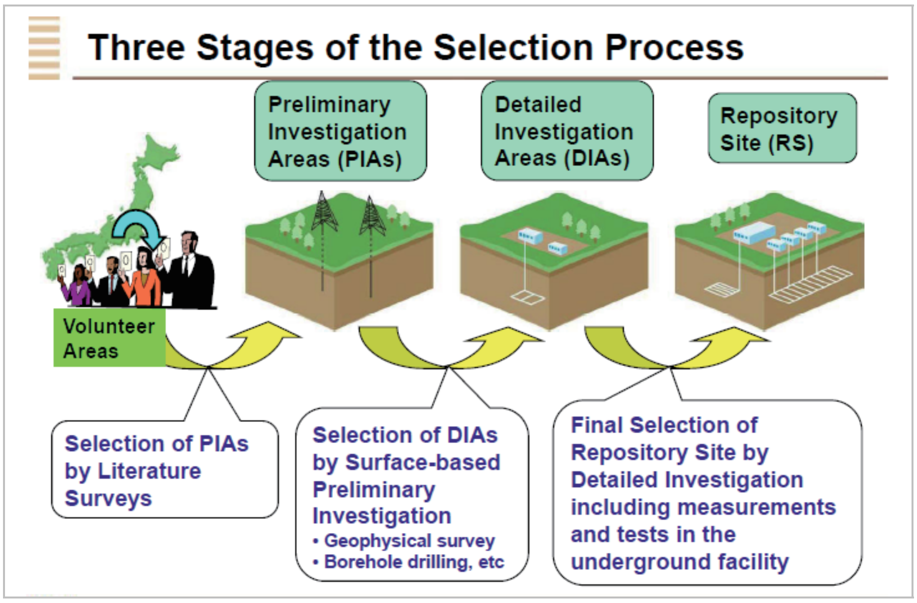


Figure 1 The three stages of NUMO's site selection process

Since 2002, when NUMO issued the open call for volunteers, various discussions for potential applications have been conducted. After the withdrawal of the application of Toyo town, the government has decided to play a more active role, inform and encourage candidate municipalities to volunteer for LS. Pro-active measures were taken to enhance PR and confidence building activities; for example, currently countrywide PR activities are taking place such as the METI Energy Caravan.

The stepwise refinement of the safety case as the programme moves along the three stages was explained. An integral part of this refinement are also the RD&D activities; these are performed in cooperation with R&D organizations; which is organized through the coordination council on geological disposal (METI). The expectations from NUMO regarding RM can be summarised as:

- RM is a central part of ensuring safety as part of the disposal programme,
- RM provides measures to meet the various requirements from the stakeholders involved. Furthermore, it aids confidence building,
- As the disposal programme continues over a period of more than 100 years and the constraints and premises are likely to change within this timeframe, RM should be a continuous process with a clear long-term scope.

2.1.2 Can RMS Activate Experts? – From Educational Viewpoint

(Tokai University – Prof. Ohe)

One should consider the experts who are expected to "bring the answers". One should consider which routes are to be taken to obtain the answers. An RMS might aid in providing these answers.

In the practical application of the RMS, one should recognize that potentially to satisfy the data needs required by the system, could result in a tool that becomes very heavy and obfuscates clear thinking. One should keep in mind that the system can never become the expert, it remains a platform for the interface of human resources – the experts. It should also be recognized that there is a clear benefit in the process of developing the RMS, beyond the actual goal of obtaining the system. It is with these in mind, that an RMS can motivate and "activate" experts. A key message summarising the presentation is "Look before you seek".

3 Session 2: RMS in different national radioactive waste disposal programmes (Chair: S. Vomvoris)

3.1 The Requirement management System for the geological disposal programme and the development of NUMO-RMS

(NUMO – H. Ueda)

Highlights of the presentation (Appendix 3)

The objectives and expectations with respect to RMS in the context of the whole programme management are explained in Figure 2. Here a distinction is made between scope management and quality management. The RMS should be also linked to the schedule management and human resource management (Figure 2).

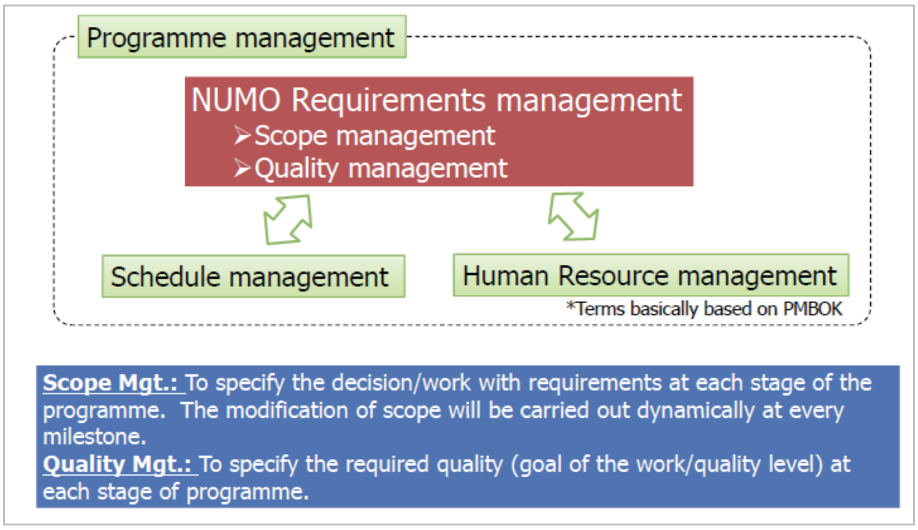


Figure 2 Vision of requirements management at NUMO

Development of the RMS started in 2005. First activities focussed on specifying NUMO's needs for such a system and evaluating existing software (in this particular case Doors®). In order to satisfy NUMO's needs and links of RMS with other management tools within its programme, NUMO concluded that it would be more beneficial to develop its own dedicated system. In 2006-2007, the trial version of the current version was developed. In this last stage of the project (2008-2009), the development will be completed with fundamental functions for practical use, including a first demonstration work.

Examples of the applications of NUMO RMS are:

- Applications for fundamental decision making,
- For repository design/performance assessment (PA),
- For R&D management.

The developed RMS should:

- Assist RM work by NUMO staff through information management,
- Be suitable for the stepwise approach of the Japanese programme.

Within the whole sequence of decisions to be taken by NUMO, the one for site selection is the most important decision-making issue in the stepwise siting process (see Figure 1). This can be considered then as the "driver" behind the current RMS developments.

In terms of organization of the requirements, a hierarchical approach, the requirement breakdown structure, is followed as shown in Figure 3. The rank and contents of requirement breakdown structure are given in Figure 4.

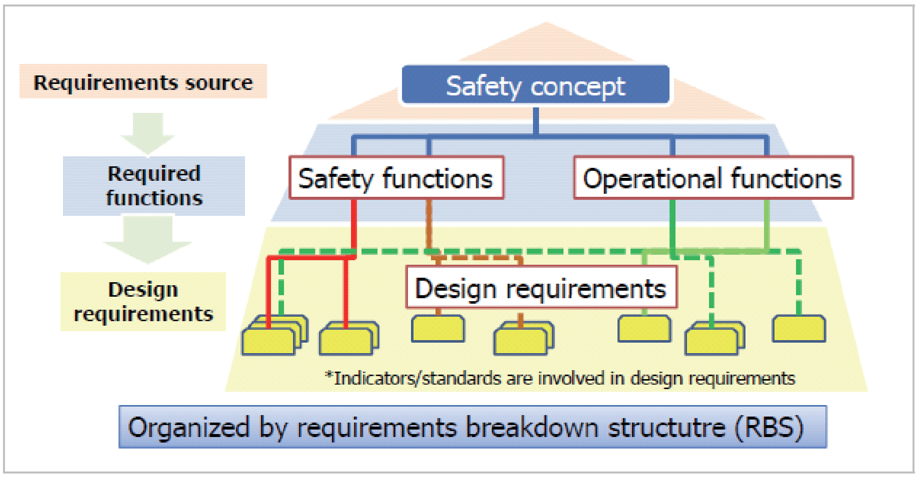


Figure 3 Explanation of the requirement breakdown structure

Rank of requirements		Contents (examples)
Requirements source	Source of requirements	Legal (Act/regulation law) Demands from local municipalities
	Concept of the geological disposal	Isolation (incl. isolation and containment in WS-R-4) Multibarrier system
	Program constraints	40,000 units of HLW can be disposed for about 40 years
Required function		Safety function Operational function
Design requirements	•Design requirement	Requirements for the design of each component
	•Design indicators •Criterion	Indicators and criterion for design

Figure 4 The rank and contents of requirement breakdown structure

In order to meet the requirements, the following steps are needed:

- The work (design/evaluation) should be carried out to fulfil the requirements,
- The fulfilment of requirements should be argued with measures, the synthesis of evidence, and the evidence itself.

It is recognized that some arguments may depend on the site-environment and the engineering alternatives, which implies that one can develop an RMS generically only up to a certain point (or hierarchical level). In any case however, how to fulfil the requirements should also be described in the measures.

The next steps in NUMO's RMS development are:

- Re-attribution of design requirements/design indicators for the specific site under the new RM methodology,
- Link with KMS (see 3.6) and application of RD&D outcomes,
- Practical operation of the RMS tool in NUMO's programme,
- Application to quality assurance.

Questions

The first question focused on the clarification of the system usage and whether the intention is to use it as a decision-making or a decision-support system. It was replied that the system should be seen as an important tool to discussion with all stakeholders and demonstrate how these are met. Here stakeholders could be seen as external groups, or internal groups, for example the safety analysis group, the engineering group etc.

It was argued that if the system usage is aimed to be very broad one should consider the danger that at the end no one will use it.

With respect to the PDCA approach (Plan-Do-Check-Act), it is asked whether it should be known in advance how to perform the third step, also called "the validation".

The "validation" step is equivalent to confirming the compliance of the suggested decision with the requirement. The definition of this step is in progress.

3.2 The SKB RMS and its Status

(SKB - L. Morén)

Highlights of the presentation (Appendix 3)

At SKB, RMS has been developed within the spent nuclear fuel programme. The application for the Forsmark site will be in the middle of 2011. The RMS is applied mainly for the design of the facilities at Forsmark.

SKB started developing the RMS in 2001, together with the site investigations for the two candidate sites. Initially the design premises were described in one document. A trial project in 2002-2004 took place to transform this in a database. Since 2005, RMS is an ongoing activity.

Purposes of the RMS are:

- Provide correct and complete design premises for the KBS-3 repository and repository facility,
- Ensure that the KBS-3 repository and repository facility conforms to the design premises,
- Make the basis and motive for the design of the KBS-3 repository and repository facility traceable,
- Facilitate system understanding and put details in the design and design work in their context,
- Facilitate decision making and avoid mistakes in design, production and operation,

➢ Facilitate development and management.

The structure is given in

Figure 5 and is actually fairly similar to NUMO's structure. The different levels of the RMS are discussed as given in Figure 6 and examples for each level are given. For example, at the Level 5 the designer gives the information to the PA to assure that the design can actually comply with the higher level requirement.

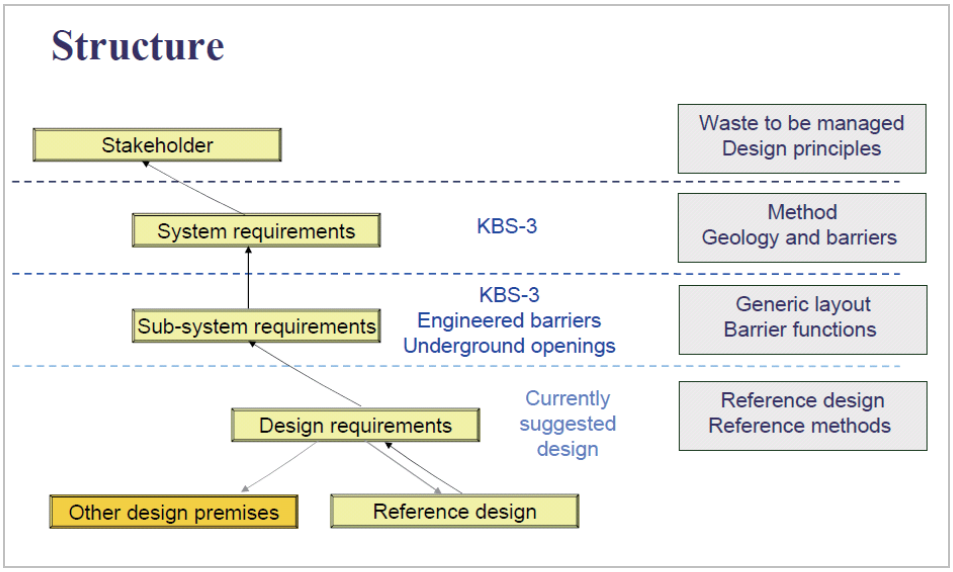


Figure 5 Structure of the SKB RMS database

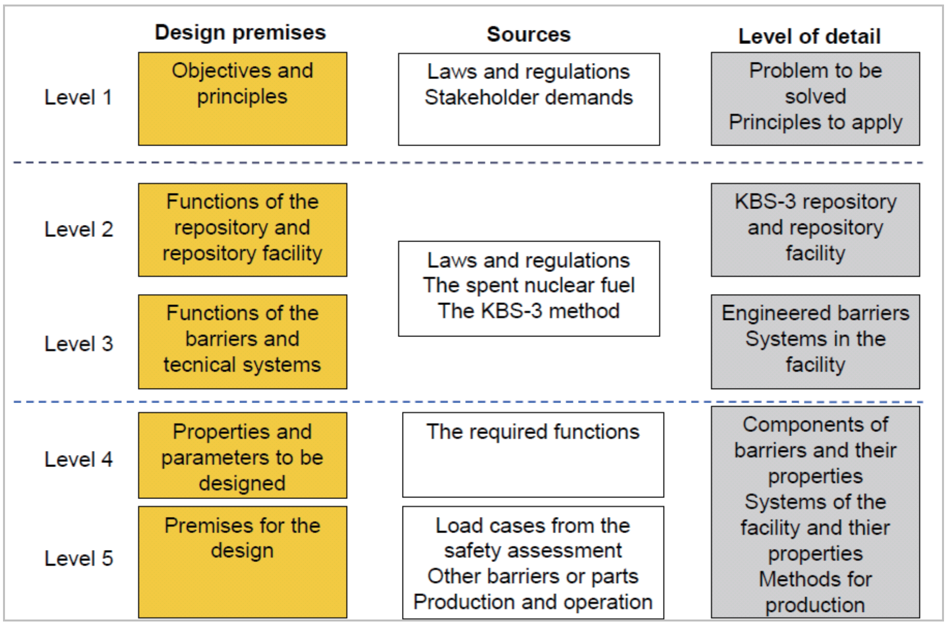


Figure 6 Levels of requirements defined in the SKB database

Requirement attributes are given to all the requirements at each level. These can be review status or references. At the Level 4 (Design) this can also be the decision maker and the decision document etc. The database further contains instructions, links to guiding documents and routines, concept and definitions and decisions.

The process of writing, reviewing and settling the requirements is given below (Figure 7).

The work on the database is still continuing, but the current status can be summarised as follows:

Level 1-3:

- Determined versions of all modules with stakeholder, system and sub-system requirements,
- Reviewed by SKB's legal advisors and technical experts,
- Sub-system requirements are currently up-dated.

Level 4 and 5:

- Design requirements for all barriers of the final repository and all systems in the facility – not formally determined,
- Reference design specifications – not formally determined.

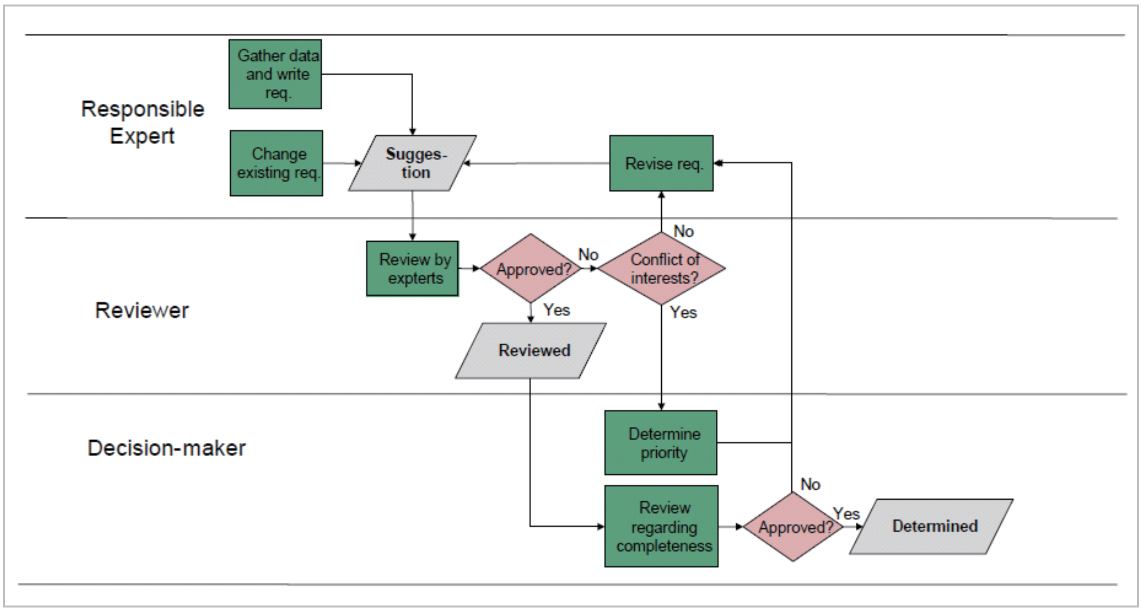


Figure 7 Process of writing, reviewing and settling the requirements in the SKB RMS

Other design premises are:

- Determined version of design premises from the long-term safety assessment,
- Specification of spent fuel to be deposited – not formally determined.

Open issues are still the definition of the workflows and the definition of the amount of information that one wants to keep in the system. One should be aware that all information included should be checked and, if necessary, updated on a regular basis.

Questions

It was asked whether the RMS can be used proactively (for example, define lower level requirements) or retroactively (for example, document decisions made) or in both ways. The high level requirements can be probably defined anyway; but the lower level requirements seem very specific and strongly linked to the KBS-3V case (one of the SKB's EBS concept for the vertical emplacement). For example, what would happen to these requirements if the decision would be taken at SKB to change to reference case to KBS-3H(one of the SKB's EBS concept for the horizontal emplacement)?

The answer for the second part of the questions was that the top level and second level requirements are identical in both KBS-3 cases. Certain parts of the facilities of the repository system will be the same also. With respect to the first part, SKB would suggest to start earlier with the RMS than they did, so that it can be implemented more fluently and, in that sense, also more proactively.

With respect to development and testing of the RMS, it was asked whether it can be used for generic cases. If a case is still generic, would it be better to implement and test the system retroactively, accurately documenting the current decisions?

The system can be used in a generic case and it can be used proactively mainly for the highest levels. To write lower level design premises, a first set of information needs to be compiled. The lower level design premises are strongly linked to, and specify, the reference design. Consequently, they will develop as site investigations and technical development proceeds. A first set can be regarded as an example of a possible solution and can be used proactively.

It was asked whether the stakeholders' requirements are updated continuously and if yes, what effect would this have to the work progress.

In most programmes, the high-level requirements are not expected to change very often, or suddenly. But in case such changes do occur, for example decisions regarding reversibility or long term monitoring, these would need to be integrated at the top level and will have consequences at lower levels. The RMS can be very helpful is such a case; however, this situation is expected not to happen on a regular basis.

With respect to the top level requirements, these are defined by the stakeholders and the regulator and thus outside the influence of SKB. How are the low level requirements defined?

This is a long process with many people involved whereby all come with their own mindset, which occasionally does not facilitate an expedient decision making. SKB is still working to improve the procedure of the definition of the lower level requirements.

3.3 How ONDRAF/NIRAS approaches RMS: Framework & Key elements

(ONDRAF/NIRAS - W. Wacquier)

Highlights of the presentation (Appendix 3)

In this presentation framework and key elements regarding the approach to RMS regarding three elements are given (Figure 8):

- Safety and Feasibility Strategy,
- Feasibility Assessment Methodology,
- Safety Assessment Methodology.

In the safety and feasibility strategy (Figure 8), system development and assessment of its safety and feasibility are constrained both by *boundary conditions* and by a number of *strategic choices* made by ONDRAF/NIRAS (which are themselves constrained by the boundary conditions). These strategic choices and the boundary conditions are translated into *requirements* related to the disposal system. *System development* and *safety and feasibility assessment* are carried out in parallel and iteratively.

System development starts with the development of the *safety concept*, on the basis of existing knowledge and understanding and of the requirements on the system. The safety concept, together with the requirements, is translated into a structured set of *safety and feasibility statements*, used as a guiding tool throughout further system development and safety and feasibility assessments. With the safety concept as a basis, the development of a *repository design* is carried out iteratively. The repository design includes the description of the design of the proposed disposal system and the implementation procedures and is developed as far as is necessary to support the safety and feasibility case.

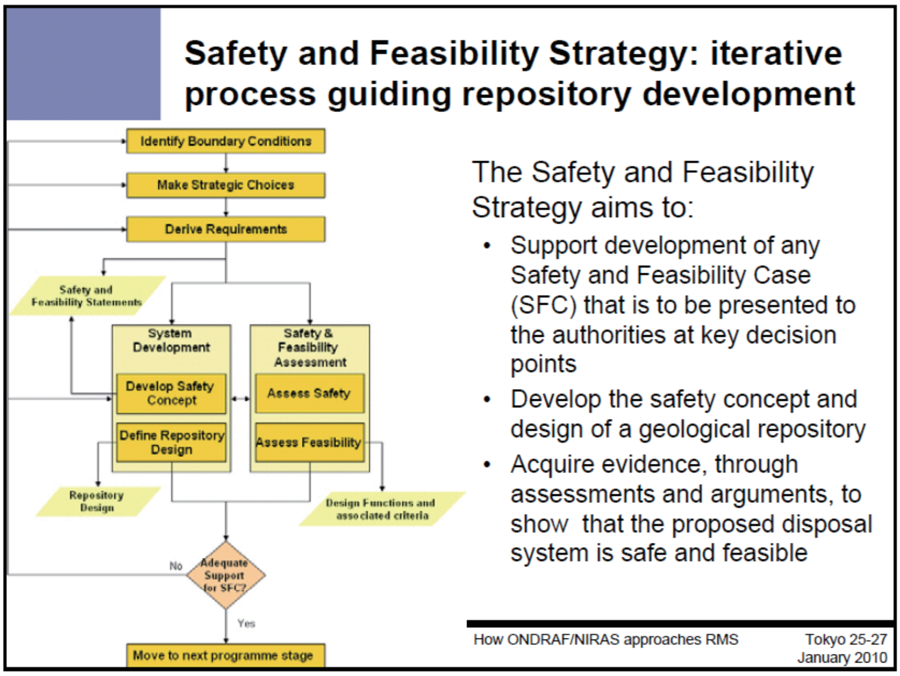


Figure 8 Overview of the safety and feasibility strategy at ONDRAF/NIRAS

Hence, the safety and feasibility statements play a central role and are equivalent to the requirements.

In the feasibility assessment methodology the feasibility statements (Figure 9) are:

- Organized in a tree structure,
- Derived from safety concept in a top-down approach,
- Covering all activities (removal primary package → institutional control).

Design functions are identified at the lowest level of the feasibility statements and are characterised by criteria allowing to:

- Evaluate if the feasibility statement (requirement) will be met,
- Identify potential open questions,
- Specify a specific design (ref. or variants).

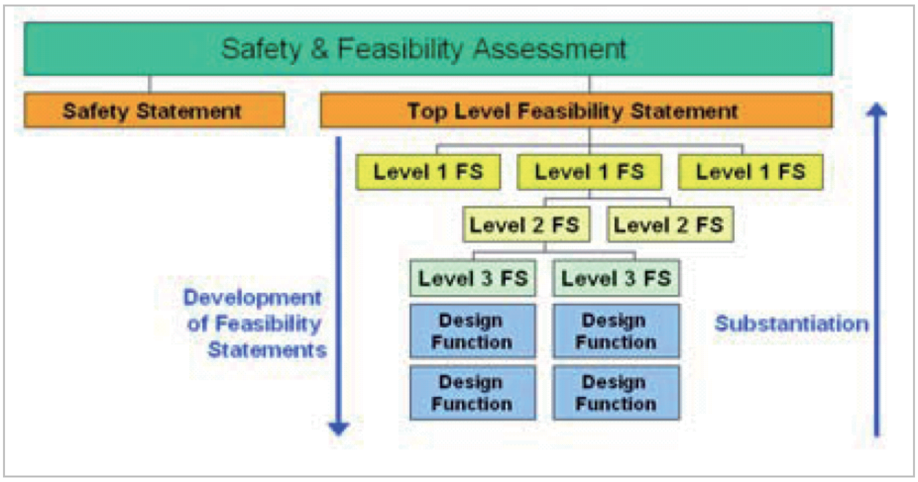


Figure 9 Relationship between the feasibility statements and the design function

The feasibility statements and the design functions are characterised by the elements as described in Figure 10.

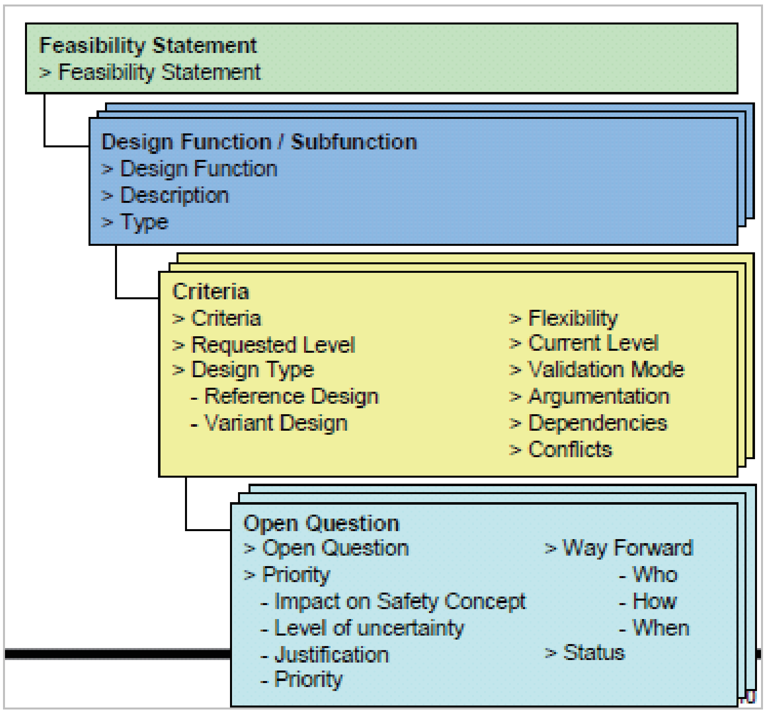


Figure 10 Identification of the design functions

The completeness check is obtained by cross checking with respect to story boards and the state of the art describing the relevant best proven practices.

It can be concluded that:

- Safety and Feasibility assessment methodologies developed based on the strategy,
- Requirements are managed through the safety and feasibility statements,
- In the Feasibility assessment methodology, statements are further derived into functions and associated criteria to demonstrate the feasibility.

Questions

It was asked whether the elements of the RMS are similar to the elements of the safety case (safety and feasibility statements), or if there are other elements not explicitly mentioned herein.

This is indeed true as the safety and feasibility statements form the RMS and are the drivers of the safety case.

With respect to tools used, does ONDRAF/NIRAS use a specific software package?

ONDRAF/NIRAS is utilising currently R. Vignette, a knowledge management tool; the tool is currently used as part of the development of the safety case and it includes the safety and feasibility statements with their argumentation and the remaining open questions. For the functions and criteria Excel is used currently. Regarding the functions and criteria, first the data will be collected to "fine tune" the feasibility assessment methodology which is under development and then the specific ONDRAF/NIRAS needs for software will be defined for the management of the data.

3.4 Requirements Management System in Posiva: Status, Open Issues and Future Plans

(POSIVA – T. Jalonen)

Highlights of the presentation (Appendix 3)

Posiva has already over 40 years of site investigations and site selection behind it. At the end of 2012, the application for the construction licence will be submitted. The goal is to start the disposal in 2020.

The objective of the RM project has been to design, implement and introduce a systematic process and an information system to manage the requirements related to the geological disposal of spent nuclear fuel in Finland. Before the start of the project the site was already selected.

The desired result of the project is an information system with a database which

- Includes all the significant requirements, the reasoning underlying them, and the existing specifications to fulfil them,
- Enables an easy review of compliance between separate specifications and requirements,
- Contains information of dependencies between requirements,
- Enables a systematic review and documentation of influence derived from alterations in requirements,
- Enables implementation of RM as part of day-to-day operations within organization.

Because of the close collaboration between SKB and POSIVA, for the development of the RMS POSIVA was able to rely on the SKB experience and started in 2006. The DOORS software was chosen as the preferred software. The structure and contents of the RMS were developed in 2007.

The system structure is described in Figure 11.

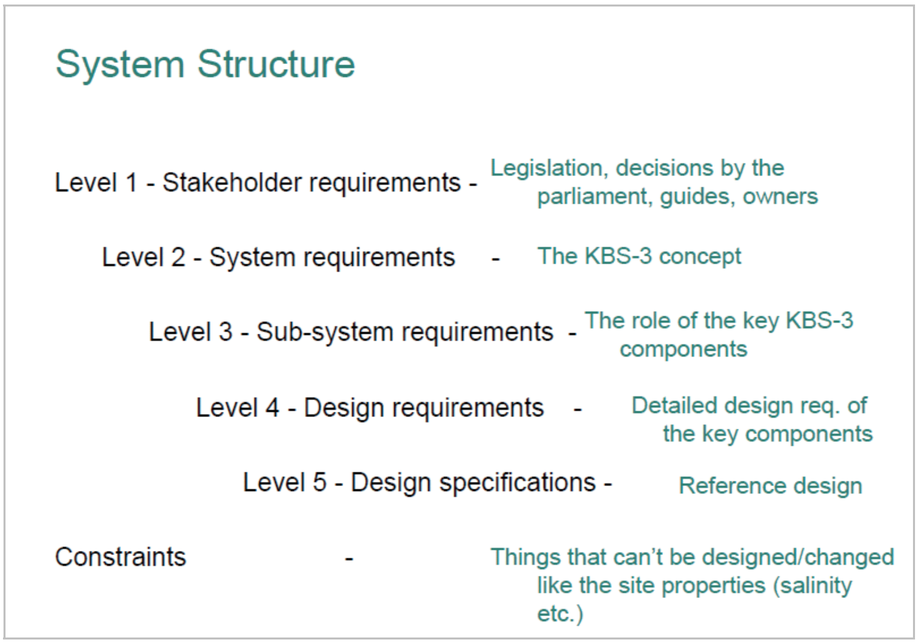


Figure 11 System structure of the POSIVA RMS

The process of the definition of the requirements was the following:

- The project team gathered the Stakeholder requirements (Level 1) and the System requirements (Level 2) (3rd Qtr 2007),
- A person responsible for gathering the requirements for each sub-system (Level 3) was nominated,

- Canister – Development manager,
- Buffer – Development engineer,
- Backfill & Closure – Development Coordinator,
- Technical facilities – Design engineer,
- Technical systems – Design engineer,

- Gathering existing requirements for levels 3-5 in each sub-system group was done during 2007,
- Specifying the structure and the contents and defining dependencies for the RMS.

In its current status, approximately 1500 requirements are in the RMS database. The stakeholder and system requirements are completed, and certain subsystem requirements are also defined. A web access has been created for access for the contractors.

Current open issues are:

- The sub-system requirements that have been compiled but need to be re-organized and approved: technical facilities, technical systems, new sub-systems Transportations and Operations,
- Actual verification of the requirements and specifications: some demonstrations done, some planned.

Future plans are:

- To link the existing sub-system requirements (connections defined) and add specifications,
- To transfer ownership of the RMS to Posiva's Safety Unit,
- To rehearse the change management process (see also Figure 12).

Questions

It was asked which type of the work is done in house and what is done by consultants.

The basic research and design is done at Posiva. So system engineers are involved at Posiva and these are able to judge which information can be entered in the system. At Posiva, the system engineers and the people feeding in the requirements are indeed sometimes the same person, but there is always a higher level management control on what is actually entered in the system.

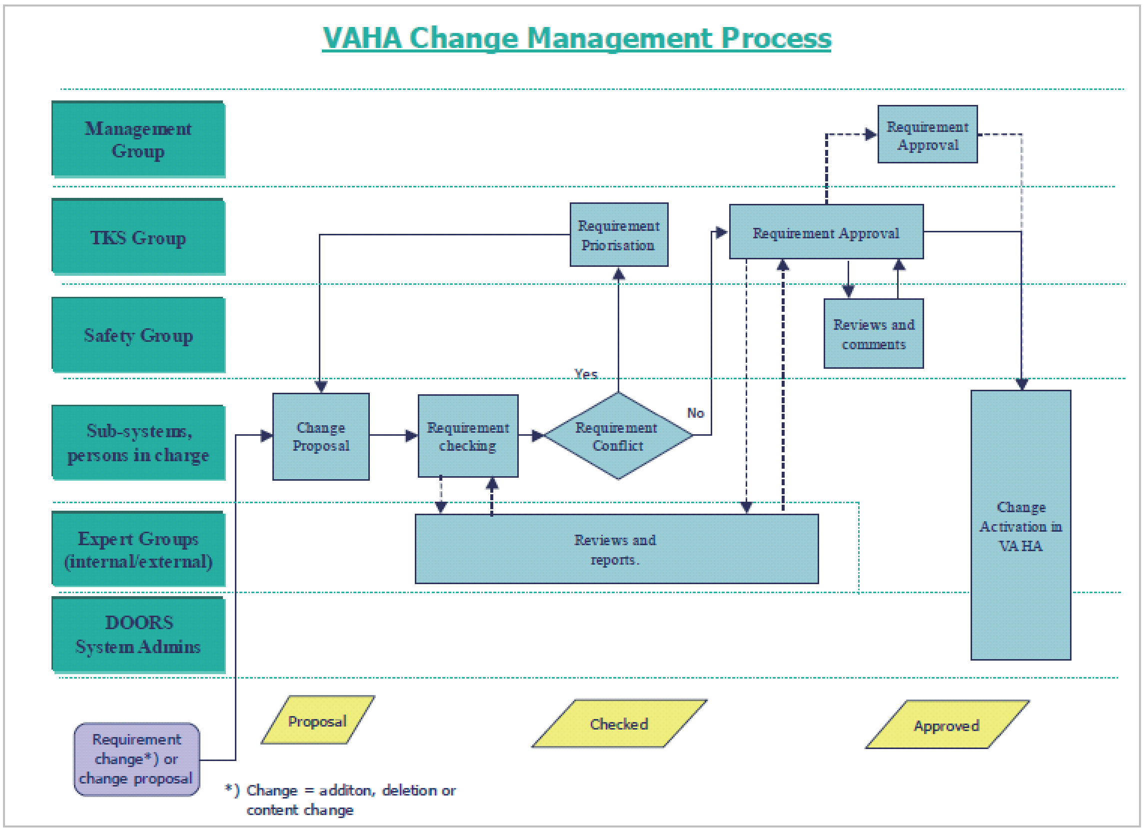


Figure 12 The change management process as proposed for the POSIVA requirement management system

3.5 Requirement management at Nagra

(Nagra - P. Zuidema)

Highlights of the presentation (Appendix 3)

The current situation in Switzerland, including the ongoing site selection process, was summarised.

The major goals of the RMS are:

- Nagra wants to have a complete overview on all relevant requirements (compilation of requirements),
- For each of the issues at hand, Nagra has to ensure that all relevant requirements are considered (specification of requirements).

Operational goals of the RMS are:

- Facilitate repository development (incl. transparency for communication with stakeholders),
- Facilitate decision making (clarify objectives),
- Ensure traceability of decisions (motivation for decisions),
- Ensure a continuously updated basis (and help keeping track of changes).

Thus, the RMS contributes to ensuring safe repositories and should provide confidence to the stakeholders involved (Nagra, other). The basic structure of the RMS, the corresponding process and the information flow are described in Figure 13 and Figure 14 respectively. RM provides also input the formal interactions with the authorities.

Basic structure of Nagra's RMS

1 For which reason?
- Laws, ordinances, regulatory guidelines, stipulations
- Instructions by owners of Nagra
- Science & technology
- Authorities' expectations
- Expectations from scientific community & public

2 What requirement? (hierarchical structure)
- Aim / purpose: Principles & functional requirement for all stages in life-cycle
- Relevant system-properties that enable fulfilment of principles & functional requirements and specific requirements (for all stages in repository life-cycle)
- Specifications (layout, material, processes)

3 For which element? (hierarchical structure)
- Waste management concept
- Repository concept (for all stages in life-cycle)
- Concept for HLW & L/ILW repositories
- Geological barrier (incl. geological situation); engineered barriers; detailed components

4 When?
- When (and at what level of detail) must compliance with requirement be reached?

5 For which (alternative) system?

Figure 13 The basic structure of Nagra's RMS

The current status of RMS at Nagra is as follows:

- RM is a process within Nagra's Quality Management system since several years,
- RM has been used in several key projects (resulting in formal reports), especially:
  - Wellenberg site investigation (1997-2000),
  - Development of waste management programme (2006-2008),
  - Site selection process: proposal of siting regions (2003-2008, continuing),

- The structure & process of RM has been a continuous development (evolutionary process, still changing) and the developments will continue,
- The requirements are documented in several external reports and internal databases (File Maker Pro, EXCEL, …),
- IRQA® (visure®) has recently been chosen as standard software (based on structured evaluation process).

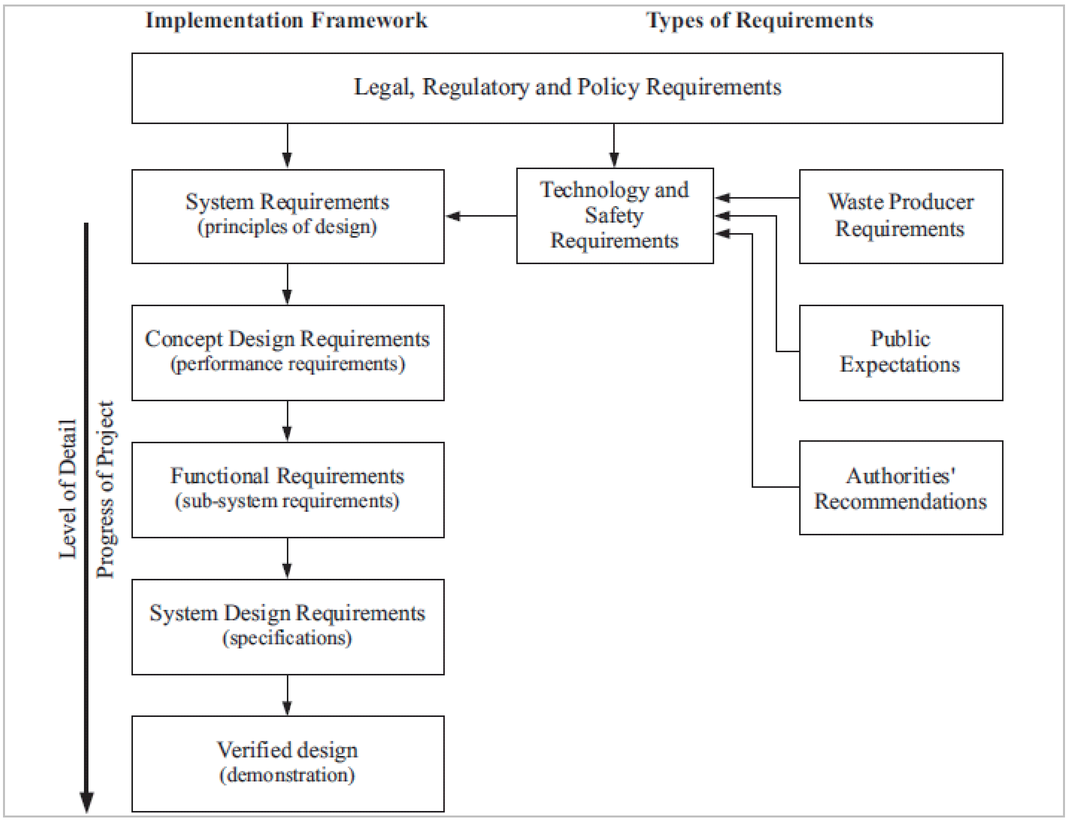


Figure 14 Information flow in Nagra's requirement management system

To summarise:

- RM is a ***process*** to derive and apply requirements; the consideration of the overall objectives and overall context is important,
- RM is part of the organization's culture: it serves to define objectives, helps to evaluate whether objectives are met and does this in a traceable manner to make the quality of the work and the corresponding products visible,
- Therefore, RM is integrated within Nagra's qualitiy management system and has to be applied in all important projects,

- A broad and appropriate structure of the RMS with emphasis on the broad objectives is of key importance. For that purpose, a hierarchical structure of the RMS has been chosen (different hierarchies in the requirements, different hierarchies in the elements to which the requirements apply).

Presently, the requirements are stored in more than one database – while their underlying scientific basis is documented in several formal reports. This will be optimised in the immediate future.

Questions

It was asked to describe the mechanism of decision making and application of RM as part of the selection of the siting regions.

RM can contribute to decision making but it is then important to provide the time for a certain number of iterations in the requirements definition (and the requirement resolution) process; often, it turned out that the first draft was not yet fully satisfactory.

In the recent process of selecting the siting regions, the government guidance asked for the development of the necessary requirements in a first step (based upon 13 broad criteria), and then siting regions were identified in a step-wise narrowing-down process, which lead to the decision of siting regions to be proposed. The overall process has thus been split in a sequence of steps / sub-processes. Setting of priorities played an important role: thus, the corresponding requirements were divided into "need to have", "nice to have" and "to be considered in optimisation".

3.6 KMS - Overview, Knowledge Base and KM Toolkit

(JAEA – K. Hioki)

Highlights of the presentation (Appendix 3)

In Japan, major projects are currently running in parallel:

- Near-surface facilities operating at Rokkasho and interim-depth repository for higher activity waste in preparation for licensing,
- Deep repositories for HLW & TRU waste to be implemented following response to call for volunteers,
- Integrated concept for industrial and research wastes in development,
- Extensive supporting R&D, including 2 URLs.

This information has to be dealt with a limited and aging work force. Therefore JAEA started developing the KMS (Knowledge Management System) database.

Specific concerns that are addressed in the system are:

- Radwaste generalists learned to use the KMS tools with support of IT experts only where needed,
- Recent advances in computing systems (hard- & software) were fully utilised and component systems were continually tested for applicability and user friendliness,
- Tools facilitate dialogue with users and feedback serves to drive further improvement and tailoring to specific needs.

The structure and components of the KMS are described in Figure 15.

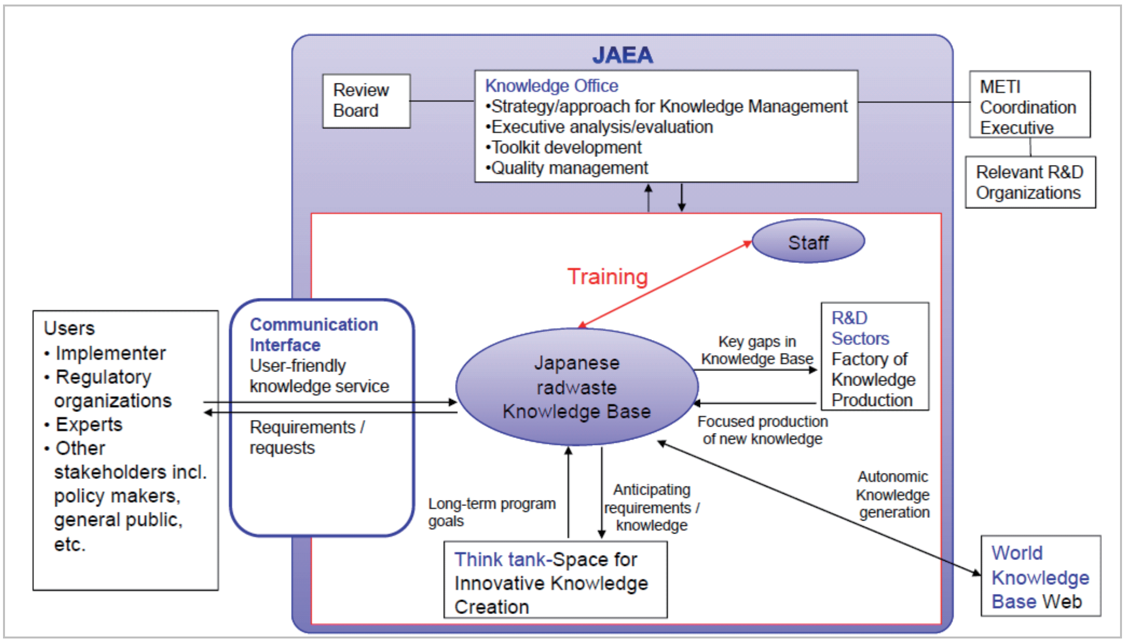


Figure 15 Structure and components of the JAEA KMS database

An argumentation model is integrated and explained based on a structure of sub-claims, counter arguments and arguments. Also the evidence of the argument is added under the form of knowledge notes.

Main applications are focussing on major areas where large flows of information must be integrated in a structured manner to provide support to the developing safety case for deep geological disposal such as: safety case development & review, site characterisation & geosynthesis, repository design & PA.

The expected evolution of the KMS toolkit is given in Figure 16.

Conclusions and future prospects regarding the JAEA KMS are:

- Significant progress has been made in establishing the KB (Knowledge Base: Databases for KMS) to support the H22 project and the tools that provide access to it,
- A number of different approaches have been examined but, to date, those based on argumentation models appear most generally useful,
- Effort is focused on establishing as much automatic functionality as possible, but it is accepted that practical application requires a hybrid approach - facilitating the work of project teams is the main goal,
- Some major challenges have not yet been addressed,
  - KB freezing, archiving and security,
  - Smart search engine development,
  - Development of interface with knowledge producers.

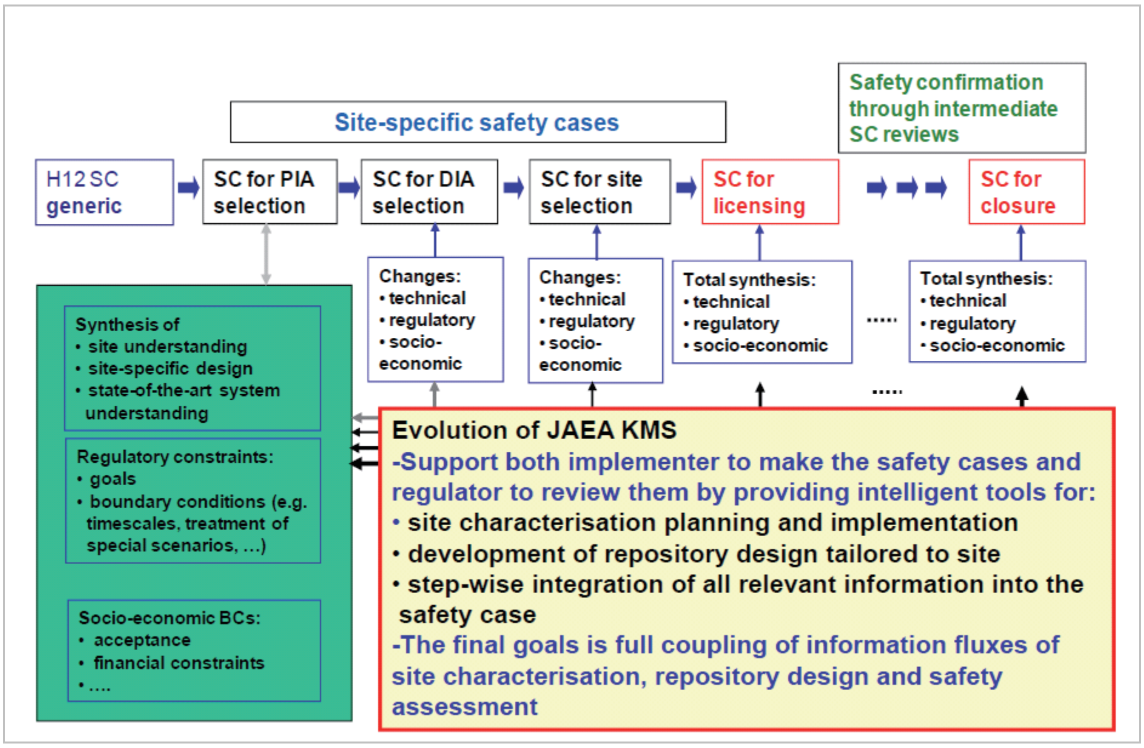


Figure 16 Expected evolution of the KMS toolkit

Questions

It was asked how the KMS is (or will be) connected to the RMS of NUMO.

The key component/interface would be the argumentation model. It is planned that the argumentation model will interact at different levels with the RMS from NUMO. The exact linkage is the topic of interactions and discussion between NUMO and JAEA.

As a user, the strategy for making decisions might be different than the one programmed in the RMS through the "argument-counter argument" system. How is this addressed?

In case new questions are formulated, these can be uploaded. However, currently the system is in use by the JAEA community only and questions cannot be added by outsiders.

Who is responsible for the information that is entered in the KMS and how is its quality guaranteed?

The attribution of the responsibility is the same as is the case with the authorship of reports. The writer remains the owner. The system just reflects the current knowledge.

The confidentiality and how to manage this confidence levels is still a point for discussion though.

4 Session 3: RMS in other industries – what can we learn? (Chair: S. Vomvoris)

4.1 Application of RMS for the management of major projects; examples from the Aerospace industry

(Parsons Brickerhoff Ltd - H. O' Grady)

Highlights of the presentation (Appendix 3)

The presentation gives an overview of the application of RMS in non-nuclear industries, particularly aerospace where RMS are well established. The essential components of an RMS are people, processes and tools (Figure 17) – RM software is a component.

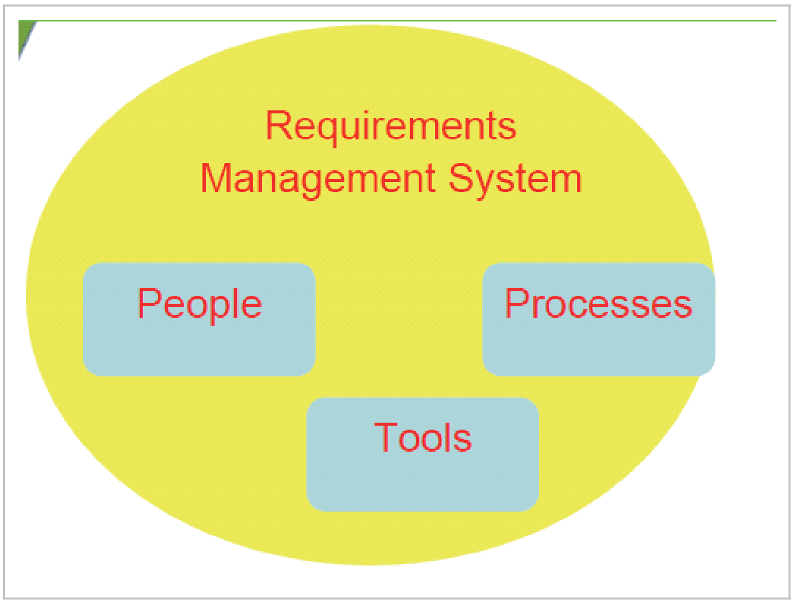


Figure 17 Components of an RMS

The RMS should be defined just as any other engineering process:

- RMS should be defined and developed using Systems Engineering methods,
- RMS should support the key project milestones and the Engineering Lifecycle,
- Key features:
  - Ease of use,
  - Minimal additional staff / resources,
  - Full integration into project process (after pilot has proven itself),
  - Defined Inputs and Outputs,
  - Provable benefits,
  - Ability to provide the inputs needed for the project / engineering milestones.

The RMS needs to be designed for and to operate in a project context (Figure 18). The "customers" for the RMS therefore include project managers.

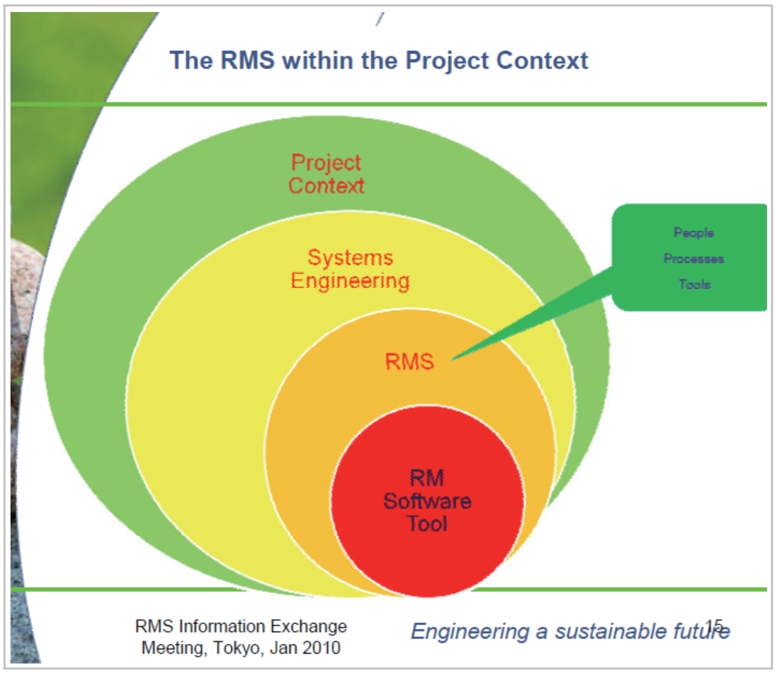


Figure 18 Embedding of RMS in the project contents

Some thoughts regarding staffing and organizational structures:

- Need some specialist staff, and good project management,
  - "Project management" skills vs "data entry and data maintenance",
  - "do it" types vs "plan it" types,

- Careful definition of the roles of other functions: IT, Projects, Commercial, Configuration management, Engineering, and Project management,
- Role of Chief Systems Engineer,
- Training and familiarisation are key,
  - For management as well as engineering staff,
  - And possibly the External Client & Regulators,
- Organization of the RM function should map onto the External Client organization,
  - Foster External Client liaison at low levels of the organization.

During the full implementation stage of the RMS one should be aware that:

- Approach must be flexible as: staff may change, stakeholders and regulators do not behave ideally, funding will change, or organization will change,
- At this stage the RM team must be fully part of the project team,
- The RMS and the RM software must be the primary systems/tools used (For example. must not let people keep using WORD or Excel and only use the RMS as an archive).

The main points regarding RMS in other industries, which are potentially also applicable to the radioactive waste business, are:

- RMS should be seen as a formal project,
- Identify customers and stakeholders,
- Application should be tailored to the people involved, the product, the external client, existing internal processes,
- Staged approach to implementation is preferable,
- Identify benefits of the RMS and then demonstrate them,
- RM software tool specified around the overall RM process,
- Use RM processes on the RMS itself.

Questions

It was recognised that the role of the Chief System Engineer is of key importance; it was asked how this person can be selected.

They often select themselves by showing the ability to think at the top technical level in terms of building blocks rather than detail. However, they should be able to understand the detail when necessary and be able to communicate with technical experts, project managers and clients. The best training of new people in this role is through mentoring. There are two common models for a Chief Systems Engineer: a) an engineering manager leading a team of technical staff who defines the requirements, justifies the system-level design decisions and proves the requirements have been met; or b) a specialist, without staff responsibilities, who has an in-depth technical knowledge of the system and is able to advise the project manager on the top level design trade-off.

Is RMS really working in practice in other industries?

This is indeed the case, for example, in aerospace and rail industries, most development and construction is done under fixed price contracts to deliver a contractually defined performance. The contractual assumptions, risks and price are therefore defined by the requirements in the RMS, and this is recognized by clients, project managers and commercial managers. The need for an RMS is often written into the *Invitation to Tender*. Generally, in each project, whatever the topic, an agreed set of requirements gives confidence to the developer that they are focussing their resources onto delivering what the client wants. It also provides stability for the project by ensuring that any changes are agreed by all stakeholders before any additional work is done.

How is the process of changing the requirements best defined? One should avoid that one is fighting against a moving target?

At certain points in the project programme, the set of requirements is frozen into a "baseline" and this requirements baseline is then used for the design. Changes to requirements are then recorded in the RMS software tool, but are not addressed in the design until they have been formally accepted and a new baseline has been generated. This ensures that the design work addresses a relatively stable set of requirements.

What would be the biggest challenge of RMS in radioactive waste disposal area?

There are two that spring to mind based on the discussions so far:

a) Definition of the system boundaries i.e. “what is the system and what is not in it ?" It is easy to expand the scope of the project indefinitely, particularly when stakeholders evolve their needs. A well-defined system boundary will permit the project funding and resources to be planned will also allow interfaces with external organizations to be defined. Conversely, a poorly defined system boundary makes it hard to decide what to design, makes it hard to predict funding and resources and makes it impossible to agree external interfaces. All this can increase the project risk significantly

b) Terminology: the need for a single set of definitions to ensure good communication and reduce mis-understanding. This is especially true when people from different engineering disciplines meet and when more than one language is involved.

5 Session 4: Open forum and discussion (Chair: S. Vomvoris)

5.1 Main points discussed

The main points of the discussion session are summarised herein in terms of open questions.

What is the need for RMS at NUMO?

The aim of RMS is to raise the quality of the process of decision making and support the decision making itself. By using RMS, it will become clearer what NUMO needs to do now and in the future. The RMS will provide common understanding and generate the awareness for delivering the quality required.

The RMS system is a combination of computer-aided information retrieval and association as well as the human resources (NUMO personnel, experts etc). NUMO's structured approach is needed for the long term management of the project. All the detail does not need to be included now; however, the human interactions and the interactions with the system should be discussed in much more detail.

RMS cannot be a stand alone system; its success depends rather on how it is supported and how it supports and steers the geologic disposal project. In this stage, RMS in its current form seems an appropriate choice, but the concept of the RMS might still need change in the future.

Who would be the users and how often will the RMS be used?

A large part of the NUMO employees would use it. The intensity of using it will probably depend on the level of the employees. The intensity of working on the RMS is expected to be higher for technical project managers. Most likely, personnel at higher managerial level will access it less frequently. Overall, it is expected that RMS will contribute to creating a common understanding of what is needed for the completion of the disposal project.

Who would be the chief system engineer at NUMO managing the system?

The option is still open, it could either by a dedicated external team or NUMO could do the overall management internally. Perhaps the most preferable option is to have a chief systems engineer who is a NUMO employee, supported by suitable external experts, as the chief systems engineer role needs to be very closely embedded in the organization. The most likely candidate for the chief system engineer would be the director of science and technology.

Is the cost estimation of the geological disposal system also part of NUMO's RMS?

RMS will not manage costs at this point as the focus is on the design.

How does the hierarchical structure in the RMS work in practice? In particular, is there a chance that you do not fulfil a low level requirement and still comply with the overall requirements?

Certain implementers (e.g. ONDRAF) have next to strict requirements also so called "nice to have" statements. These could be related to ease if implementation, for example, or cost optimisation etc. In case these statements are not met the upper level requirements are still expected to be met.

In the case of Nagra and NUMO there is no need to develop all requirements to the lowest level in this stage of their project as the focus is on the site selection. However, one should make sure that there are no show stoppers at this lower level in the future. One should avoid making decisions too early in the process. A good risk management process will be helpful here.

For the current situation at NUMO, one has to substantiate, trace and qualify the decisions that already have been made (response to high level requirements), but there is no need for attempting definition of requirements at the detailed level now. A system that is flexible has to be in place.

Within the process, there will be requirement definition stages which will also include the removal of requirements that are no longer needed. There is possibility to include, for example, more than one option in the early development phase. Each option delivers the solution but requires different effort and has different types of uncertainties. Even at a top level these different options can exist.

Can a generic RMS be developed in case there is no site or host rock defined?

It is true that the boundaries in NUMO's case are not as clear as in some other countries. For developing requirements the situation is much easier if one can start with a given regulatory framework, possible concepts or host rocks; otherwise, one has to make some "strategic choices" – an approach taken by ONDRAF/NIRAS regarding the absence of regulatory framework. It is important however to write the high level requirements even before the concept is defined.

NUMO is in an early stage and some of the requirements are very qualitative; through re-iteration however, these should be refined and become more quantitative. It is important to know which requirements are derived from choices that were made by the implementer, and which are imposed externally. This will of course require effort and resources but it will be needed to start a constructive dialogue. One should avoid defining too strict requirements in the beginning. One can only construct a complete RMS once all the detail is known; but one can move in cycles.

The decision level is situated at one level higher than the level for which the requirements are defined. It is important to bring in the stakeholders in the decision making process, for example regarding the site selection process, and the RMS system can support this interaction.

5.2 Conclusion on the initial questions identified by NUMO.

As preparation for the information exchange meeting, the host of the meeting, NUMO, posed three questions to all presenters (see also Appendix 3, presentation by Dr. Kawata). The questions and a summary of the answers is shown below.

What are the lessons learnt from experiences of each organization and other industries regarding the requirements management and its operation in the programme?

- The RMS needs a clear definition both in terms of purpose and boundary conditions,
- Two of the participating organizations started implementing the RMS system in a quite advanced state of their programme. Their advice is to start earlier with its implementation as in that case the implementation will be a more fluent process,
- In general the RMS is part of the safety case, especially for the ONDRAF concept whereby the requirements are formulated as a system of safety and feasibility statements this is explicit. In Switzerland the requirements are used formally within the Sectoral Plan (Siting Region Selection), where it is also perceived as a beneficial tool for discussions with the regulator,
- Various software codes are in use by the different implementers. First the needs should be defined, then appropriate software can be selected.

How to use the RMS to meet the stakeholder requirements, how does it contribute to confidence building?

- Stakeholder requirements are generally introduced in the RMS as top level requirements (although this does not always need to be the case). In this case the updating of stakeholders requirements can be achieved a transparent way so that the consequences of changing stakeholder requirements can be shown clearly,

Which are the difficulties encountered of applying RMS in the disposal programmes? Which measures can be taken?

- It seems difficult to define the system boundaries and to define the scope of the RMS,
- The process of defining "in-house" technical requirements (Level 4 and 5) including the decision making is challenging in terms of effort required and reaching consensus,
- The RMS should be used by the people actually carrying the knowledge involved in the definition of the requirements. A system manager should keep an overall view,

- In case of the absence of a potential site or host rock, RMS can be used proactively and general requirements can be formulated,
- There is a clear need for a consistent use of terminology within the organization, and to a certain extent also on an international level. This because it is quite certain that between the different specialities in the organization, different people have a different understanding of the same terms and concepts.

6 Concluding remarks

The deliberations during the international meeting can be summarised as shown below and as presented at the end of the meeting.

- RM is an integral part of many geologic disposal programmes, its objectives should be clear and should have a broad organizational support in order to be successfully applied,
- RMS is a process, driven by human intervention, which links information in a tool which consists of a computer system and aids decision making,
- The decision to implement a formal RMS is generally an organization-internal decision and not imposed by the regulator.
- Key aspects of RMS are:
  - RMS is associated with the quality management (QM) (it can either be part of the QM System, or take an over-arching role),
  - RMS is linked with an information system/database (knowledge base: KB) and supports decision making, it is however not a decision making system,
- The most challenging aspect seems the abstraction of information coming from various specialist groups to the succinct requirements that are needed. This is especially the case for defining lower level requirements. Different organizations developed different procedures for addressing this, most of which are still under development,
- The more advanced the programme and thus the more concretely the repository system is defined the ‚easier" to specify the lower level requirements, it is however useful to start early with identifying (and tracking) the upper level requirements,
- One should remain aware that the purpose of RMS is not developing a complex RMS system, but should aid ultimately the successful implementation of the geological disposal project

("Look before you seek" principle).

Appendix 1: RMS Status and Recent Developments Information Exchange Meeting

Date:	Tuesday, 26 January 2010	
Place:	NN hall, Mita NN building, Tokyo, Japan	
Participants:	NUMO	Tomio Kawata, Hiroyuki Tsuchi, Katsuhiko Ishiguro, Hiroyoshi Ueda, Takao Ohe, Satoru Suzuki, Kiyoshi Fujisaki, Hiroshi Kurikami & others
	POSIVA	Tiina Jalonen
	SKB	Lena Morén
	ONDRAF/NIRAS	William Wacquier
	Parsons Brinckerhoff	Henry O'Grady
	Nagra	Piet Zuidema
	Secretariat	Stratis Vomvoris, Irina Gaus

Tuesday, 26 January 2010

8:50-9:30 Registration

Session 1: Introduction and Overview (Chair: K. Ishiguro)

9:30-9:35	Welcome and Opening remarks	NUMO (Dr. T. Kawata)
9:35-9:50	The management of the geological disposal programme of Japan	NUMO (Dr. T. Kawata)
9:50-10:05	Expectations with respect to a Requirements Management System (title to be confirmed)	Prof. T. Ohe, Tokai Univ.; DTAC[1]

Session 2: RMS in different national radioactive waste disposal programmes – status, open issues, future plans (Chair: S. Vomvoris)

10:05-10:35	NUMO	H. Ueda
10:35-11:00	*Coffee Break*	
11:00-11:30	SKB	L. Morén
11:30-12:00	ONDRAF	W. Wacquier
12:00-13:30	*Lunch (Bento Box)*	
13:30-14:00	POSIVA	T. Jalonen
14:00-14:30	Nagra	P. Zuidema
14:30-15:00	JAEA KMS – Overview, knowledge base and KM toolkit	K. Hioki
15:00-15:30	*Coffee Break*	

[1] NUMO's Domestic Technical Advisory Committee

Session 3: RMS in other industries – What can we learn? (Chair: S. Vomvoris)

15:30-16:00	Application of RMS for the management of major projects; examples from the Aerospace industry	H. O' Grady

Session 4: Open forum and discussion (Chair: S. Vomvoris)

16:00-17:00	Open discussion in all the presentations
17:00-17:15	Wrap-up and end of workshop

Appendix 2: List of participants of the open session

	First name & Family name	Company or Institution
1	Tiina Jalonen	POSIVA, Finland
2	Lena Morén	SKB, Sweden
3	William Wacquier	ONDRAF/NIRAS, Belgium
4	Piet Zuidema	Nagra, Switzerland
5	Stratis Vomvoris	Nagra, Switzerland
6	Irina Gaus	Nagra, Switzerland
7	O'Grady Henry	Parsons Brinckerhoff, U.K.
8	Toshiaki Ohe	Tokai University
9	Yasuaki Ichikawa	Okayama University
10	Osamu Tochiyama	Nuclear Safety Research Association
11	Toshinori Sato	Ministry of Economy, Trade and Industry Agency for Natural Resources and Energy (ANRE)
12	Kenji Miyano	Ministry of Economy, Trade and Industry Agency for Natural Resources and Energy (ANRE)
13	Masakazu Niwa	Ministry of Economy, Trade and Industry Agency for Natural Resources and Energy (ANRE)
14	Nagatsu (tbc)	NISA
15	Sumio Masuda	Nuclear Safety Commission of Japan (NSC)
16	Susumu Muraoka	Nuclear Safety Commission of Japan (NSC)
17	Hironori Funaki	Nuclear Safety Commission of Japan (NSC)
18	Shigeyuki Saitou	Japan Nuclear Energy Safety Organization (JNES)
19	Kazuhiko Shimizu	Japan Atomic Energy Agency (JAEA)
20	Hiroyuki Umeki	Japan Atomic Energy Agency (JAEA)
21	Kazumasa Hioki	Japan Atomic Energy Agency (JAEA)
22	Takeshi Senba	Japan Atomic Energy Agency (JAEA)
23	Hideaki Osawa	Japan Atomic Energy Agency (JAEA)
24	Hitoshi Makino	Japan Atomic Energy Agency (JAEA)
25	Motoi Kawanishi	Central Research Institute of Electric Power Industry (Criepi)
26	Michihiko Hironaga	Central Research Institute of Electric Power Industry (Criepi)
27	Tomonari Fujita	Central Research Institute of Electric Power Industry (Criepi)

	First name & Family name	Company or Institution
28	Hiromi Tanabe	Radioactive Waste Management Funding and Research Center (RWMC)
29	Kenji Terada	Radioactive Waste Management Funding and Research Center (RWMC)
30	Hidekazu Asano	Radioactive Waste Management Funding and Research Center (RWMC)
31	Hitoshi Owada	Radioactive Waste Management Funding and Research Center (RWMC)
32	Kimitaka Yoshimura	Radioactive Waste Management Funding and Research Center (RWMC)
33	Tai Sasaki	Japan Nuclear Fuel Limited (JNFL)
34	Yoshihiro Miyauchi	Japan Nuclear Fuel Limited (JNFL)
35	Tomio Kawata	Nuclear Waste Management Organization of Japan (NUMO)
36	Kazumi Kitayama	Nuclear Waste Management Organization of Japan (NUMO)
37	Hiroyuki Tsuchi	Nuclear Waste Management Organization of Japan (NUMO)
38	Katsuhiko Ishiguro	Nuclear Waste Management Organization of Japan (NUMO)
39	Akio Tamura	Nuclear Waste Management Organization of Japan (NUMO)
40	Hiroyoshi Ueda	Nuclear Waste Management Organization of Japan (NUMO)
41	Kenichi Kaku	Nuclear Waste Management Organization of Japan (NUMO)
42	Takao Ohi	Nuclear Waste Management Organization of Japan (NUMO)
43	Satoru Suzuki	Nuclear Waste Management Organization of Japan (NUMO)
44	Kiyoshi Fujisaki	Nuclear Waste Management Organization of Japan (NUMO)
45	Hiroshi Kurikami	Nuclear Waste Management Organization of Japan (NUMO)
46	Takao Ikeda	JGC Corporation
47	Kiyoshi Oyamada	JGC Corporation
48	Hideki Kawamura	Obayashi Corporation
49	Shoko Yashio	Obayashi Corporation
50	Susumu Kawauchi	MHI Nuclear Engineering, Co. Ltd
51	Shigeki Fusaeda	Science Solutions International Laboratory, Inc.
52	Yuji Morikawa	Web I Laboratories, Inc.

Appendix 3: Presentations

Session 1

Introduction and Overview (Chair: K. Ishiguro)

Geological disposal programme in Japan (T. Kawata, NUMO)

Geological Disposal Programme in Japan

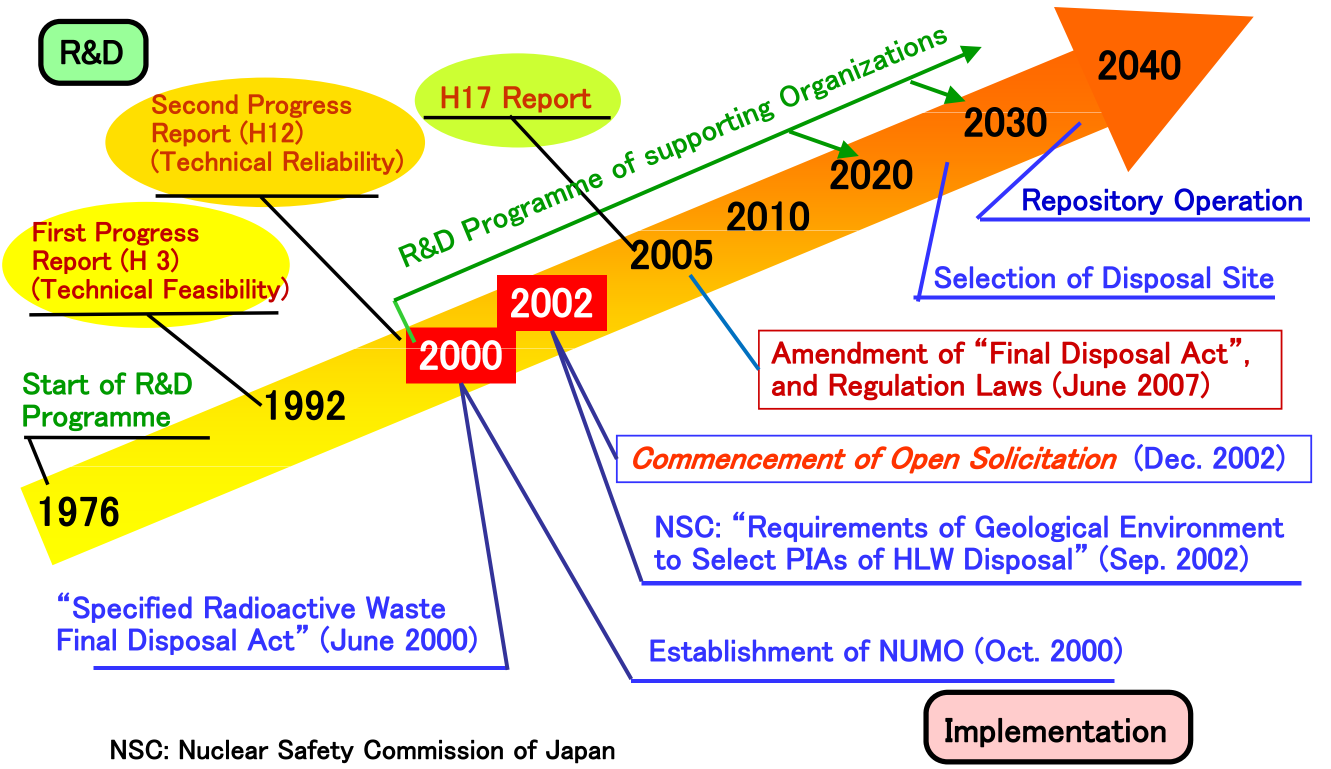
Tomio Kawata

Executive Director
Nuclear Waste Management
Organization of Japan (NUMO)

26th January 2010, Tokyo

RMS Status and Recent Developments
Information Exchange Meeting

Evolution of the Japanese HLW Disposal Programme

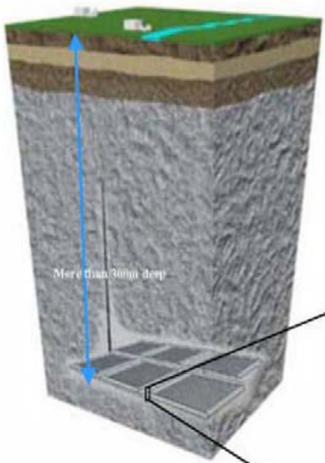


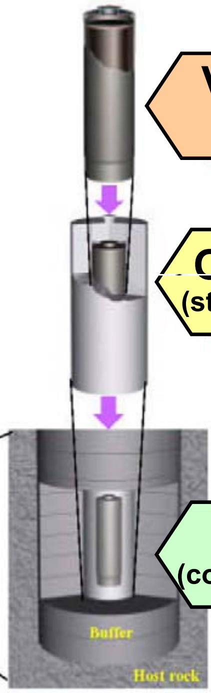
NSC: Nuclear Safety Commission of Japan

Multi-barrier Disposal System

Engineered Barriers

Natural Barrier
Host rock located deep underground



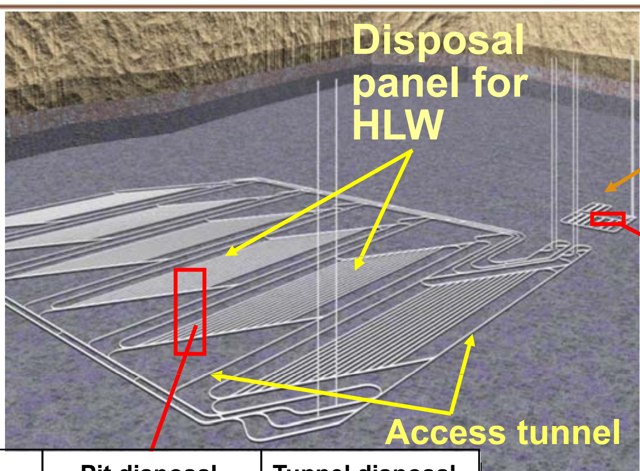


Vitrified waste
- Immobilize radionuclides in glass matrix
- Assure extremely low dissolution rate

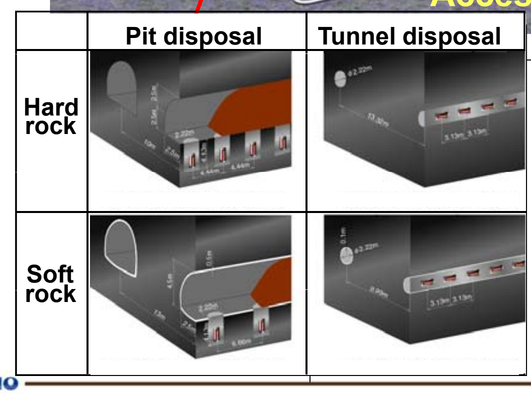
Overpack (steel container)
- Prevent vitrified waste from contacting with groundwater at least for 1,000 years

Buffer (compacted clay)
- Assure extremely low permeability to retard penetration of groundwater and migration of dissolved radionuclides
- Provide mechanical buffer

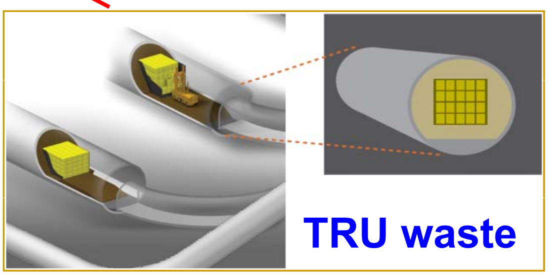
Typical repository layout (HLW/TRU co-location option)



Disposal panel for TRU waste

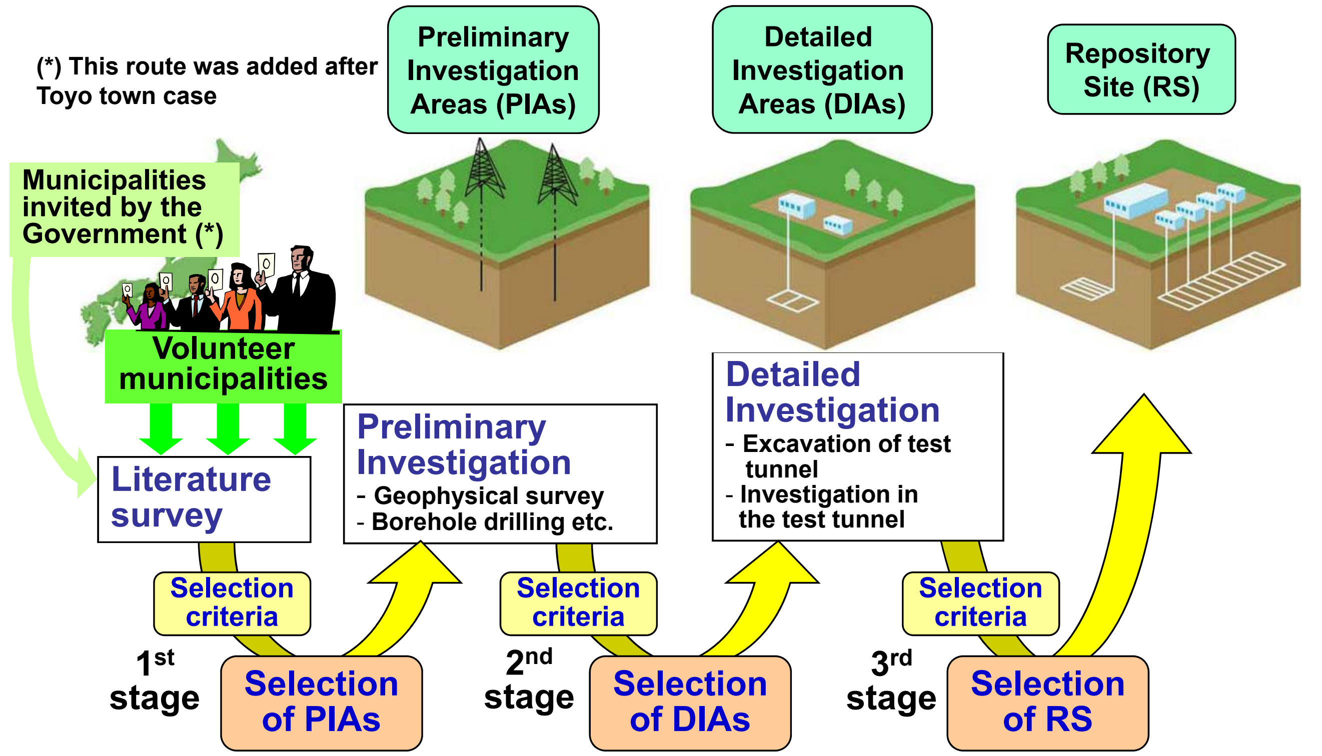


HLW



Emplacement of waste package

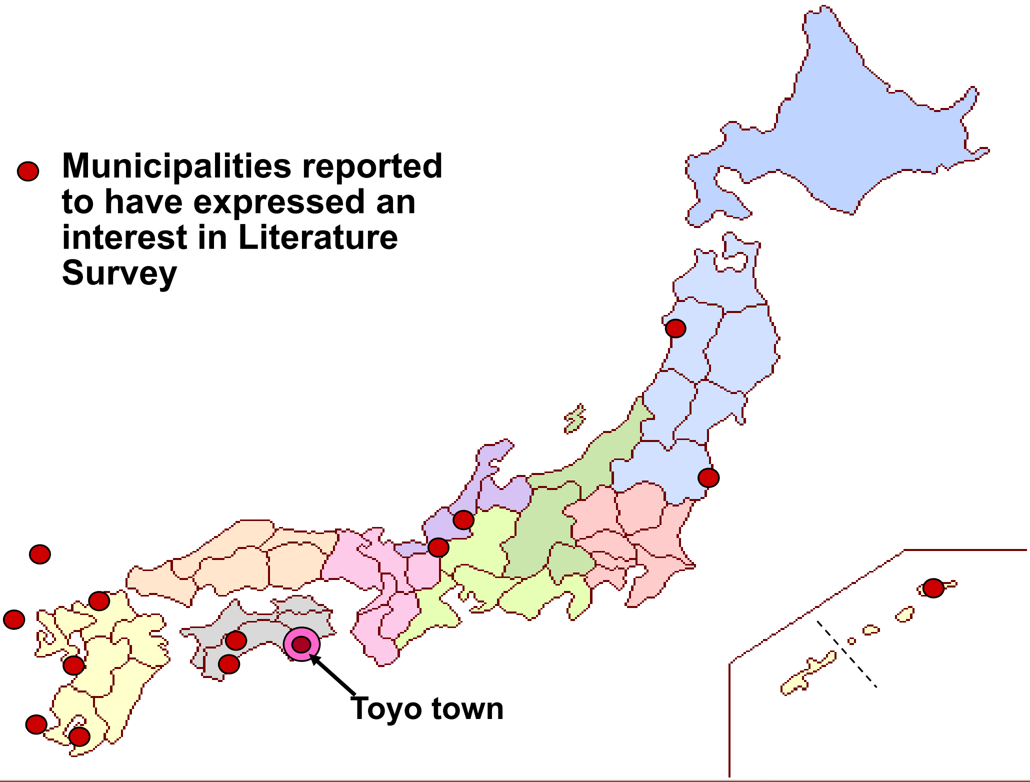
Three Stages of Site Selection Process



Topics relevant to the site selection process

- By the end of 2006, about ten local municipalities were reported to have expressed an interest in Literature Survey (LS) in four years since the start of NUMO's open solicitation , but none lead to the actual application
- In January 2007, Toyo town became the first municipality to submit an application for LS
- Escalation in opposition activities led to the resignation of the mayor and his loss in the following election
- A newly elected mayor withdrew application and the literature survey for the town was abandoned in May 2007
- Reflecting the lessons learnt, METI radioactive waste sub-committee recommended enhancement measures for HLW disposal program in November 2007
  - ✓ Addition of the system where the government can nominate candidate municipalities for LS
  - ✓ Measures to enhance PA and confidence-building activities

Locations of municipalities expressing interest since 2002



Country-wide PA Activities

METI* Energy Caravan : 46 times
METI Workshop : 20 times
NUMO Panel-discussion : 46 times
NUMO Workshop : 18 times
(FY2007-09)

Panel-discussion

Workshop

*METI: Ministry of Economy, Trade and Industry

NUMO's Basic Safety Philosophy

Safety Principles:

- Protect human health and the environment present and future
- Do not impose undue burdens on present and future generations

Basic policy for ensuring safety

- Appropriate selection procedure of disposal site
- Appropriate design, construction and operation of repository
- Appropriate assessment of safety

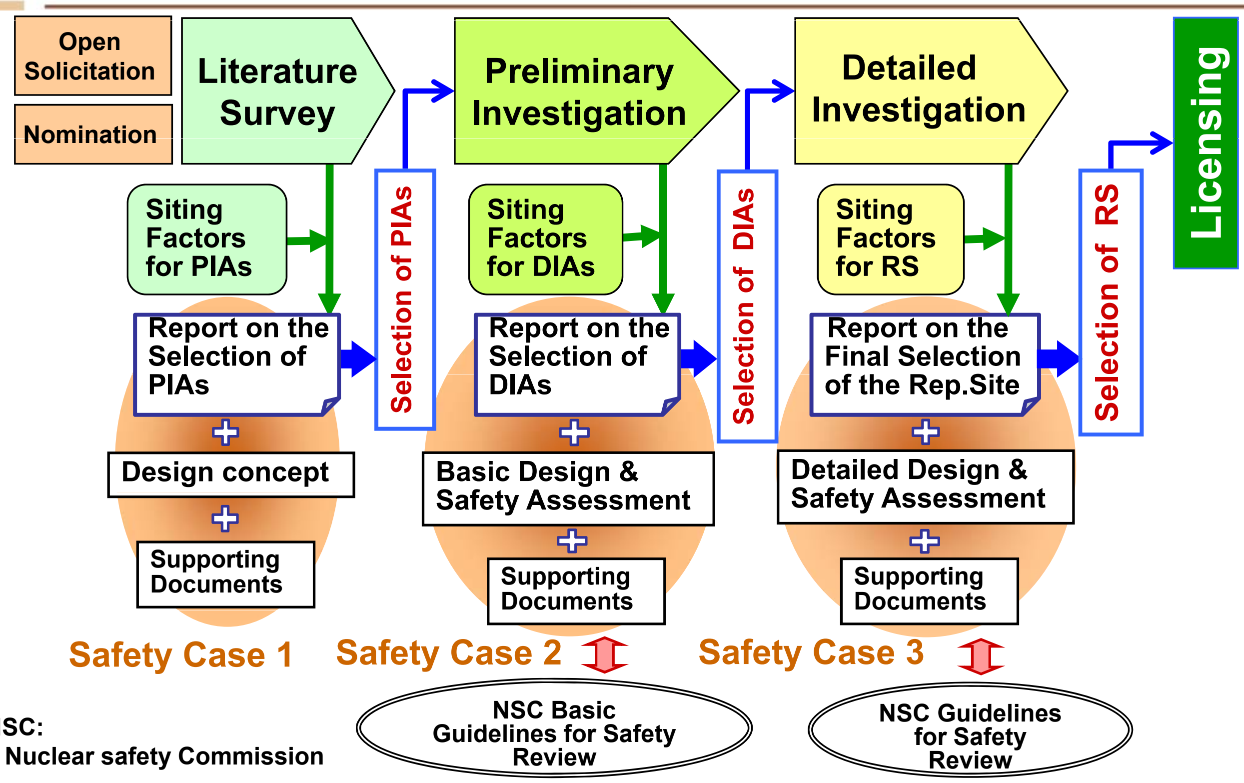
Basic policy for promoting understanding of deep geological disposal

Development of social acceptance

- Active seeking of understanding and fostering a relationship of trust

- Measures to reduce public concerns

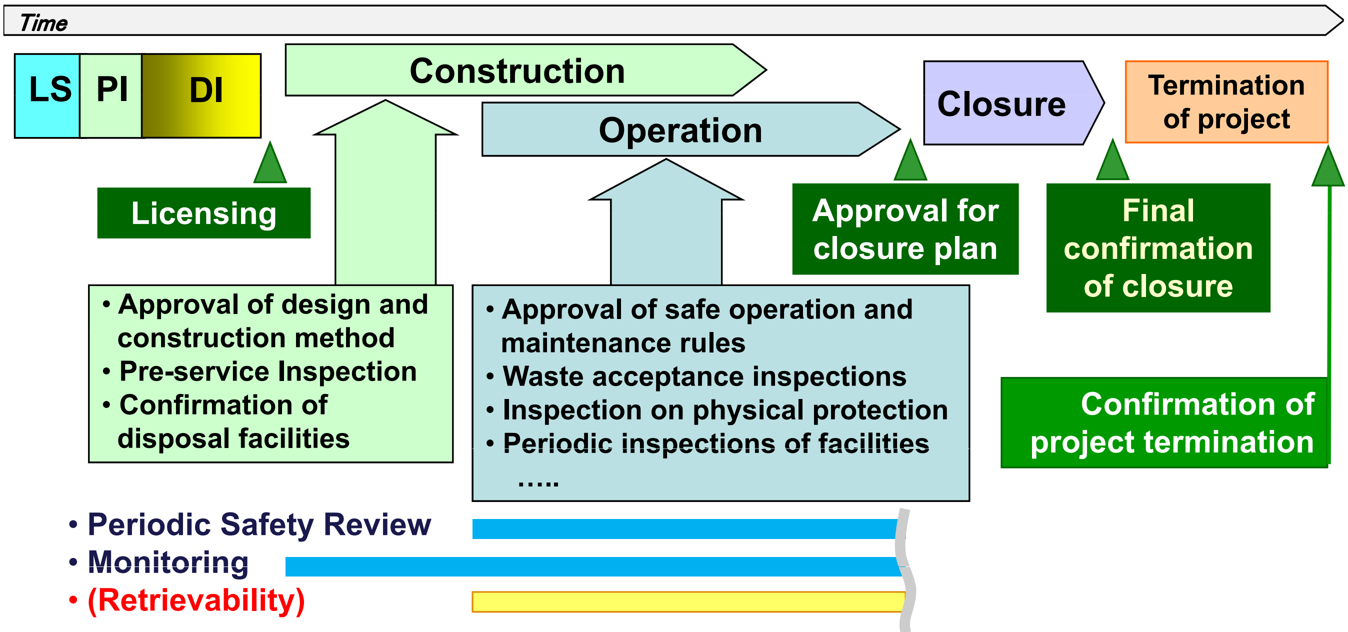
Stepwise Refinement of the Safety Case



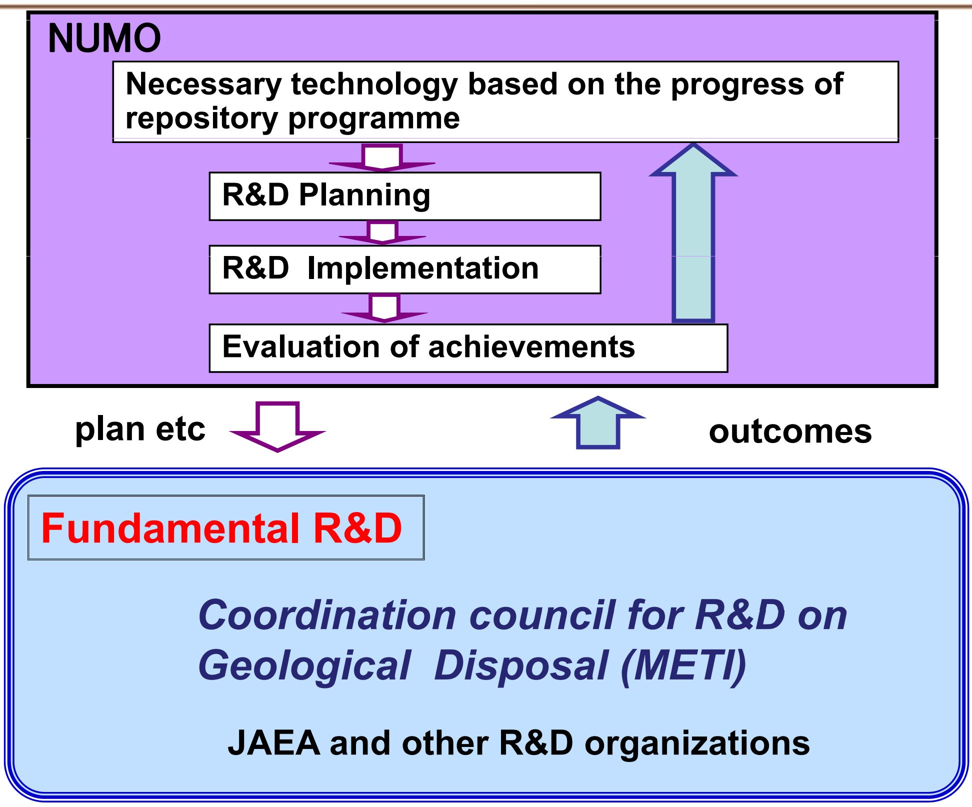
NSC:
Nuclear safety Commission

Fundamental Implementation Schedule

- Amendment to the "Law for the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors" (Jun. 2007)
- "Ordinance for the Class1 underground disposal (No.23 of METI)" (Apr.2008)
- Report on " Regulatory Framework for Geological Disposal of HLW" by NISA Sub-Committee (Jan. 2008)



Close cooperation with R&D organizations



NUMO's expectations to the requirements management

- The requirements management is one of the key components to ensure the safety in the geological disposal program.
- The requirements management provides effective measures to meet the various requirements from stakeholders in perspective. It helps to build their confidence in the program.
- As the disposal program continues over decades, the constraints and premises could change. The requirements management should be dynamically carried out with the long-term scope.

Some remarks for the info. exchange meeting

- ✓ What are the lessons learned from experiences of each RWM organization or other industries on the requirements management and its operation in each program?
- ✓ For the confidence building, how to use the requirements management to meet the stakeholder's requirements?
- ✓ What are the difficulties to transfer the common requirements management to the disposal program? What are the methodologies?

Thank you
for your attention

For further information:
www.numo.or.jp/en/index.html

NUMO

Session 2

RMS in different national radioactive waste disposal programmes – status, open issues, future plans (Chair: S. Vomvoris)

1. NUMO
2. SKB
3. ONDRAF/NIRAS
4. POSIVA
5. Nagra
6. JAEA KMS

1. NUMO

The requirement management for the geological disposal programme management and the development of NUMO-RMS

H. Ueda, S. Suzuki, K. Ishiguro, H. Tsuchi

Science and Technology Department
Nuclear Waste Management
Organization of Japan (NUMO)

26th January 2010, Tokyo

RMS Status and Recent Developments
Information Exchange Meeting

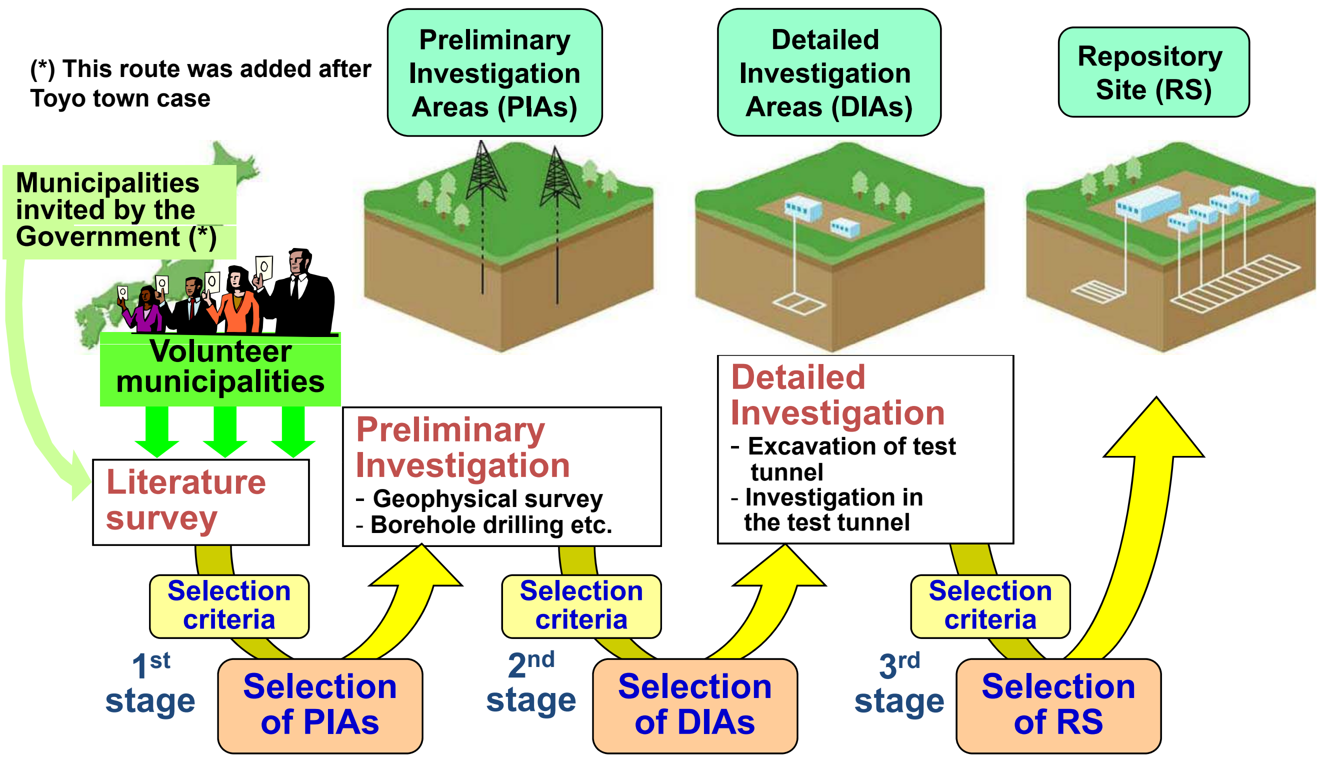
Contents

1. Objectives and expectations
   - ✓ Needs for Requirements Management in NUMO
2. Status of developments and progress
3. Practical experience with application
   - ✓ Managing the requirements
   - ✓ Requirements Management System of NUMO
4. Next step
   - ✓ Link with KMS and application of R&D outcomes

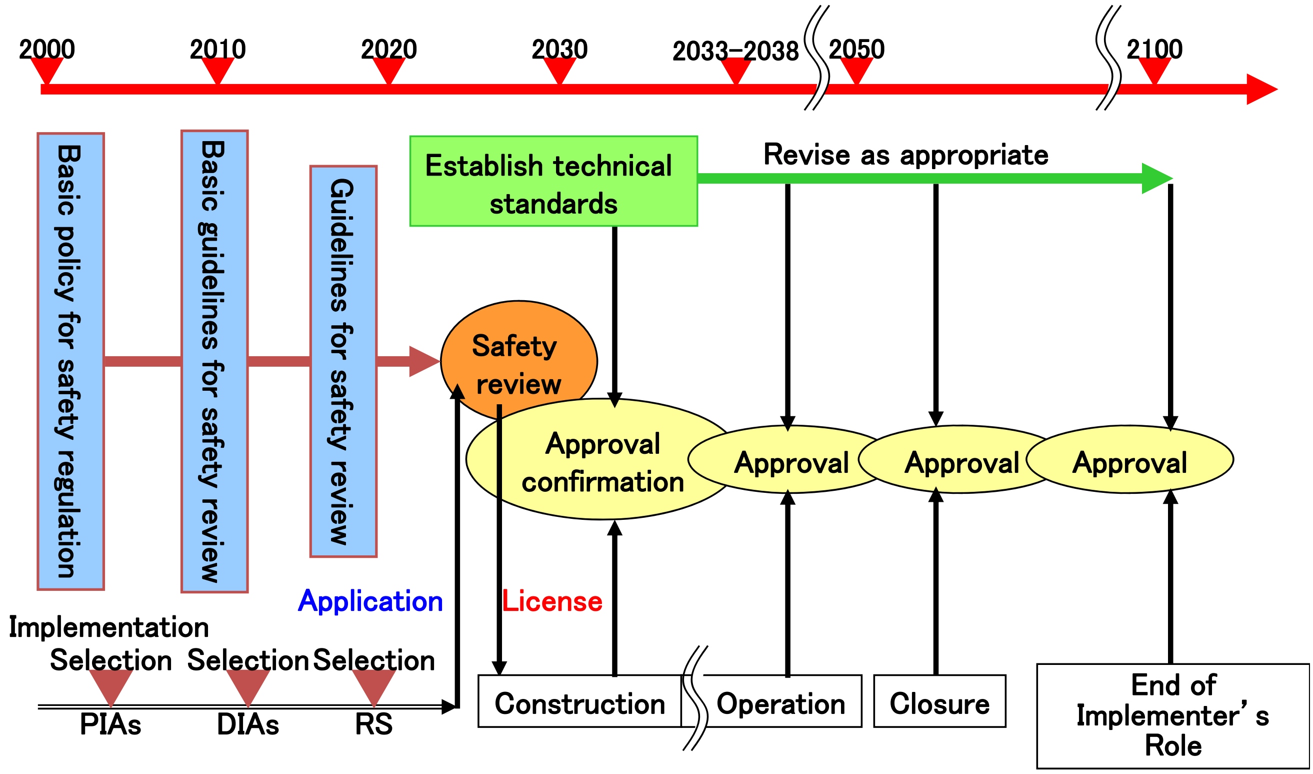
NUMO's expectations to requirements management

- The requirements management is one of the key components to ensure the safety in the geological disposal program.
- The requirements management provides effective measures to meet the various requirements from stakeholders in perspective. It helps to build their confidence in the program.
- As the disposal program continues over decades, the constraints and premises could change. The requirements management should be dynamically carried out with the long-term scope.

Three Stages of Site Selection Process



Stepwise implementation and regulations



What is "requirements" considered in NUMO RMS?

The attribution of requirements for the disposal programme.

Programme aspects
•Programme schedule
•Policy/concept
•Products (documents/works/decisions)
•Human resources/Cost
•Risk/uncertainty

R&D aspects
•R&D issues
•R&D schedule

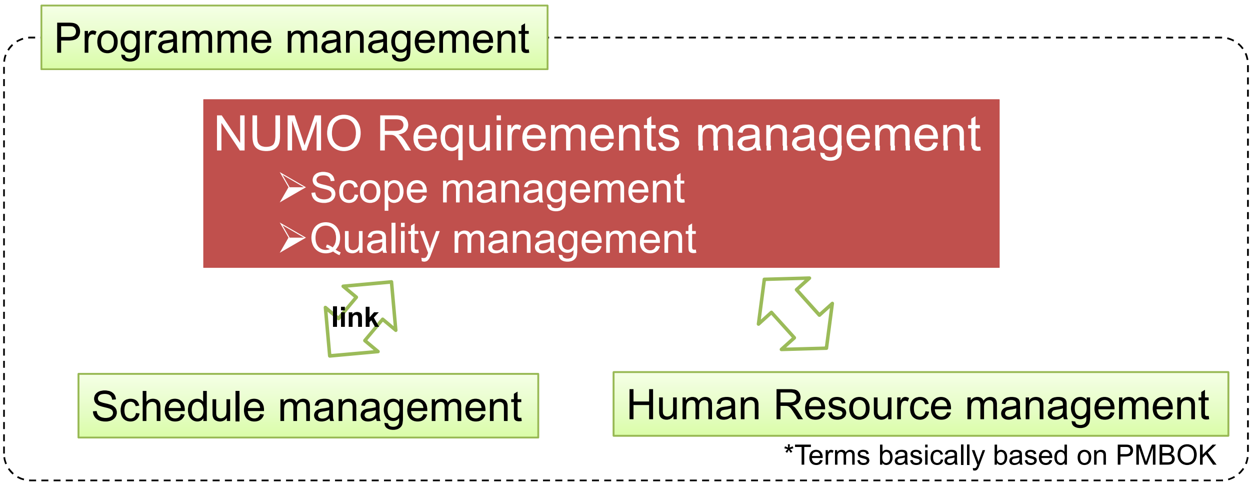
Stakeholders aspects
•Local municipalities/residential people
•Laws/ordinances/guidelines
•Authority/Knowledgeable people
•Waste producer

Quality aspects
•Quality control
•Specification for design
•Indicators and criteria
•Practicality of technology
•Scientific soundness
•Communication with stakeholders

Scope management

Quality management

What is the requirement management of NUMO?



Scope Mgt.: To specify the decision/work with requirements at each stage of the programme. The modification of scope will be carried out dynamically at every milestone.
Quality Mgt.: To specify the required quality (goal of the work/quality level) at each stage of programme.

Development of the NUMO-RMS

- **FY2005** Research on RMS initiated using DOORS®
  - Organization and description of requirements considered for engineering requirements
- **FY2006-07** Development of NUMO-RMS with basic functions for trial use
  - Need for a program management methodology for supporting decision-making, schedule management and R&D management in NUMO (**NUMO Structured Approach**; NUMO TR-07-02)
  - The trial RMS tool was developed as a central component of the PMS tool
  - The preliminary database was prepared based on requirements derived from the H12 report
- **FY2008-09** Development of NUMO-RMS with fundamental functions for practical use
  - Establish the concept for requirements management in NUMO's program
  - Providing desired fundamental RMS functions (more user-friendly GUI for input, search, review and change management)
  - Preparation of database for the design of disposal system with links to the site characterization process

Managing requirements

Modeling of requirements management

- Procedure for requirements management
- Decision-making (selection) and requirements
- Repository design and requirements
- Requirements and compliance arguments

Requirements management in NUMO's work

- **For fundamental decision-making**
  - Siting factors for site selection
  - Selection requirements for engineering alternatives
- **For repository design/performance assessment**
  - Specification of safety functions
  - Consideration of practicality of operation
  - Design requirements and design indicators
- **For R&D management**
  - Identifying and prioritizing the targets of R&D on the basis of requirements

Procedure for requirements management

Procedure for requirements management based on PDCA cycle

- ✧ **Plan: Work/requirements specification phase**
  Compile, analyze and specify requirements such as constraints, quality goals and regulations for the geological disposal program
- ✧ **Do: Implementation phase**
  Carry out the principal work of design of the disposal facility, safety assessment and geological investigations in line with the specified requirements
- ✧ **Check: Validation phase**
  Confirm whether the requirements for each action have been fulfilled
- ✧ **Act: Decision-making phase**
  After fulfilling all the requirements, a decision can be made

Classification of requirements

- **Mandatory requirements**
  - Must be fulfilled with demonstrated compliance
  - e.g. avoidance of significant volcanic activity
- **Preferable requirements**
  - Would be better if they are fulfilled, but not essential
  - Strongly linked to the selection process (sites, design, etc.)
  - e.g. the longer migration distance for radionuclides is preferable

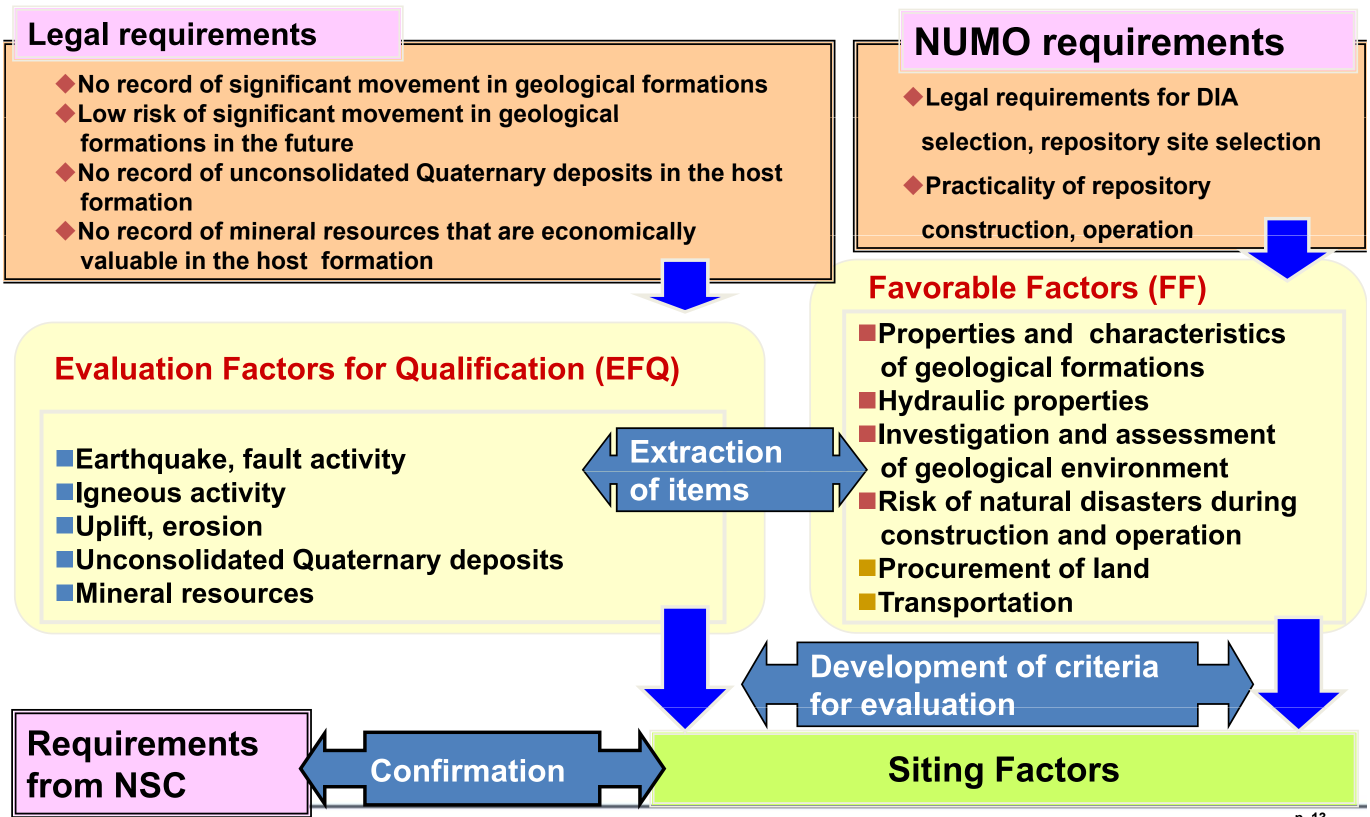
Note: Premises, constraints and conditions are also considered, but they are classified not to the requirements in our system.

Decision-making and requirements

Site selection is the most important decision-making issue in the stepwise siting process

- In 2002, NUMO published an Information Package that provided background on the HLW disposal project and initial requirements for finding a suitable site.
- One of the main documents in the Information Package addresses “Siting Factors for the Selection of Preliminary Investigation Areas”.
- Siting Factors can be used to evaluate whether an area has appropriate characteristics for a repository site and to assist in the decision of volunteer community as to whether the area would qualify as a suitable PIA.
- The scientific basis for “the Siting Factors” was published as NUMO TR-04-04 (“Evaluating Site Suitability for a HLW Repository”).

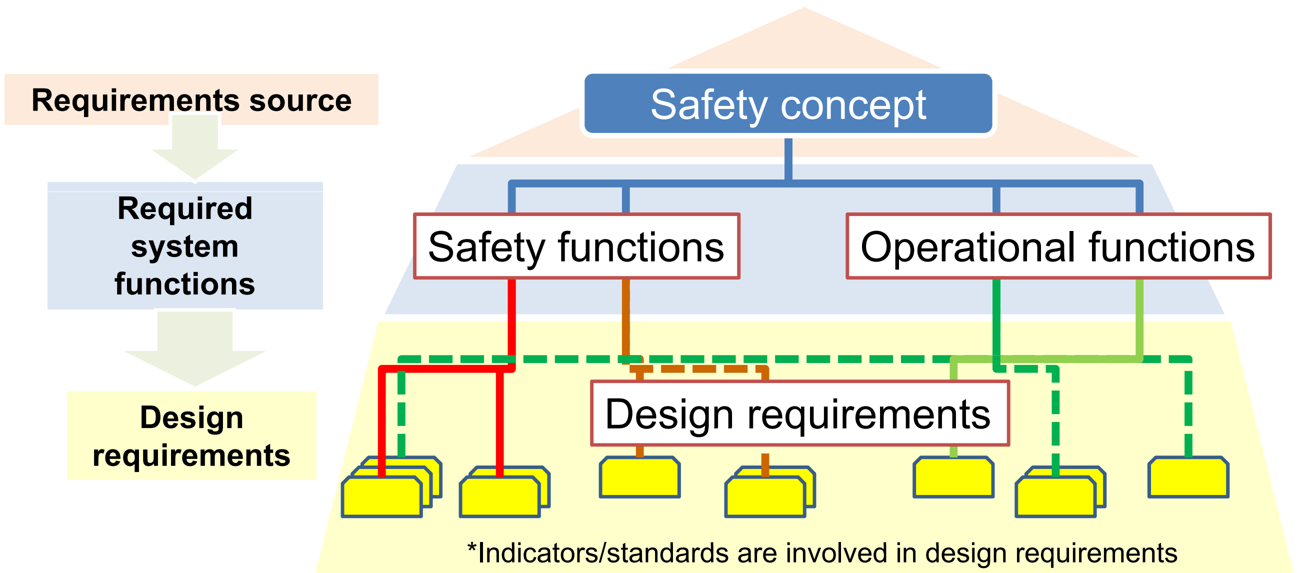
Siting Factors for PIA Selection



Repository design and requirements

- Aims of RM for repository design are to assure implementation of a safe repository with realistic operational technology.
- RM should be based on the safety concept of NUMO (isolation and multibarrier system).
- The requirements will be derived in a traceable manner from “the safety concept”.
- Operational safety through construction to closure and long-term post-closure safety are required. Trade-offs must be taken into consideration in the design.
- Decision-making on engineering alternatives such as vertical/horizontal emplacement of waste forms and the emplacement technology (e.g. PEM, block assembly) are also targeted in RM of design requirements.

Requirements breakdown structure



Organized by requirements breakdown structutre (RBS)

Rank and contents of Requirement Breakdown Structure

Rank of requirements		Contents (examples)
Requirements source	Source of requirements	Legal (laws/regulation) Demands from local municipalities/people
	Concept of the geological disposal	Isolation (incl. isolation and containment in IAEA WS-R-4) Multibarrier system
	Program constraints	40,000 units of HLW to be disposed over ca. 40 years
Required system function		Safety functions Operational functions
Design requirements	•Design requirement	Requirements for the design of each component
	•Design indicators •Criterion	Indicators and criteria for design performance

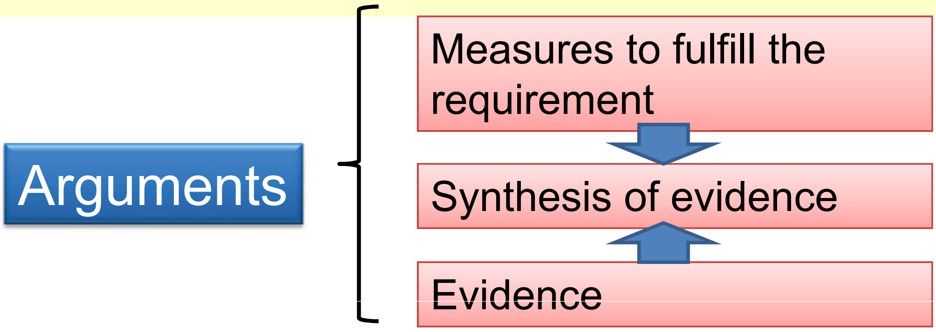
Design requirements for overpack

Required function		Design requirements
Safety functions (physical containment of radionuclides)	To prevent groundwater from coming into contact with vitrified waste for a specified period	•Containment of radionuclides in vitrified waste •Corrosion allowance/resistance •Pressure resistance •Radiation shielding •Radiation damage resistance •Heat resistance
Operational functions	No significant impact on other engineered barriers	•Sufficient internal space •Adequate thermal conductivity •Radiation shielding •Chemical buffering capacity
	Technical feasibility of manufacturing/installation	•Manufacturability •Possibility of remote sealing •Possibility of remote emplacement

(Based on JNC, 2000; NUMO, TR-04-01)

Requirements and compliance arguments

- The work (design/evaluation) should be carried out to fulfill the requirements.
- Fulfillment of requirements should be argued with compliance shown by a synthesis of supporting evidence.
- Some arguments may depend on the site environment and the engineering alternatives. It is important that specified requirements include an indication of how compliance can be demonstrated.



Need for NUMO-RMS

Basic concept for NUMO-RMS

•Assist requirements management work by NUMO staff through information management
•Suitable for the stepwise approach of the Japanese program
•“Reactive use (QM)” and “proactive use(Scope Mgt.)”

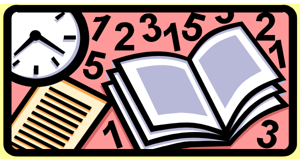
- To assist requirements management work from “work/requirements specification” to “decision-making”
- To facilitate access to the information required for work/decision-making
- To record the arguments fulfilling requirements
- To record the quality control of information
- To record the sequence of decisions/work and ensure traceability of all changes

Basic functions of the RMS tool

Record-keeping
The RMS tool records the requirements, constraints, premises, arguments and related information in a well organized structure

Support of decision-making
Ensures no critical requirements are overlooked

Change management
If any changes in requirements and decisions occur, the RMS tool identifies the related requirements and decisions and alerts the responsible persons

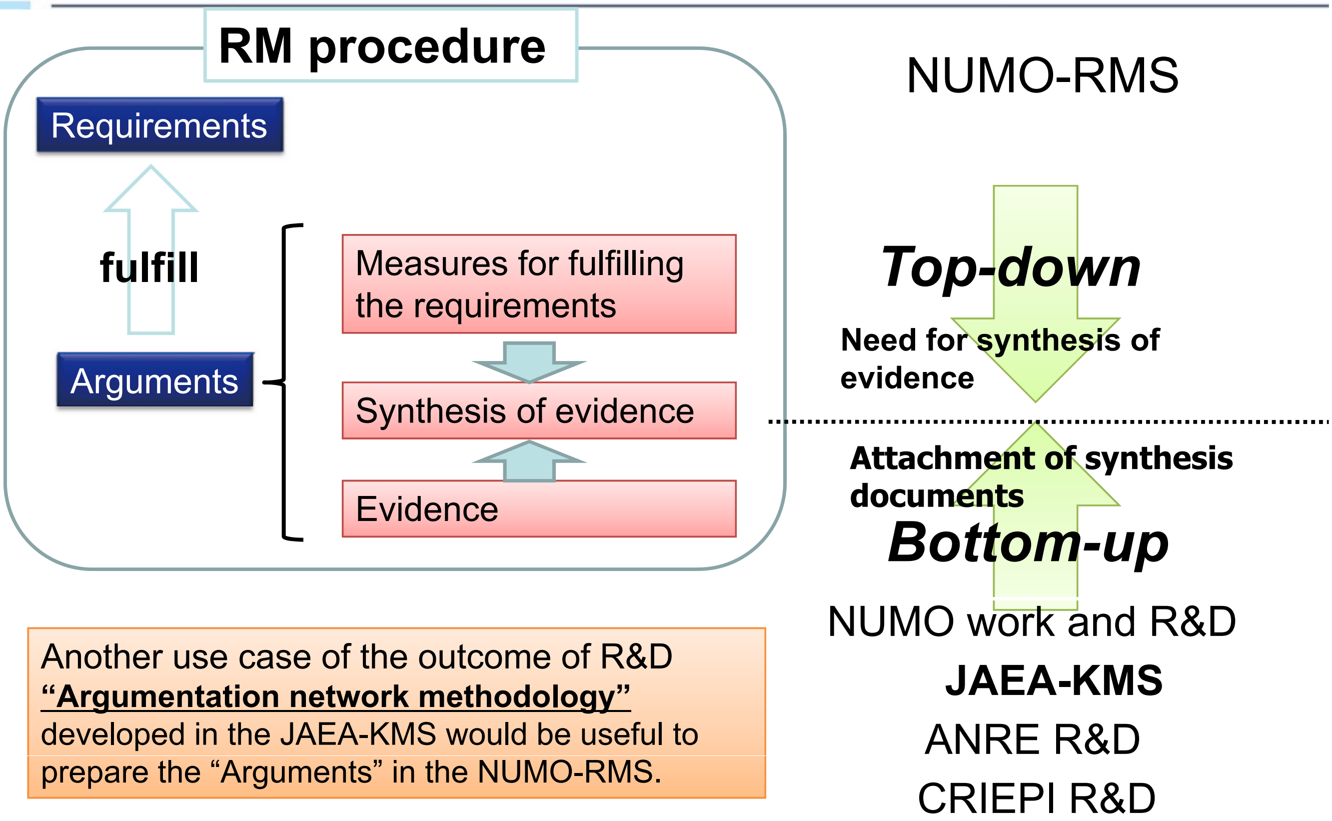


Schedule management
RMS identifies what decisions will be made in future stages and when/how/by whom the requirements should be fulfilled

Next steps

- ✓ Re-assessment of design requirements/design indicators for a specific site using the new RM methodology
- ✓ **Link with KMS and application of R&D results**
- ✓ Practical operation of the RMS tool in NUMO's program
- ✓ Application in a quality assured manner

Use of JAEA-KMS and application of R&D results



Another use case of the outcome of R&D **"Argumentation network methodology"** developed in the JAEA-KMS would be useful to prepare the "Arguments" in the NUMO-RMS.

Summary

1. Objectives and expectations
   - ✓ Needs for Requirements Management in NUMO
2. Status of developments and progress
3. Practical experience with application
   - ✓ How manage the requirements?
4. Next step
   - ✓ Link with KMS and application of R&D outcomes

2. SKB

RMS at SKB
Status, open issues and future plans

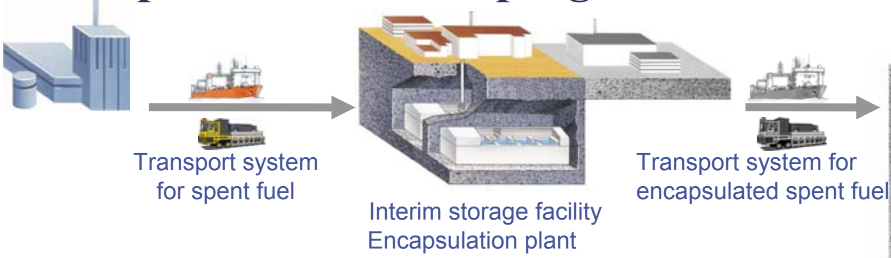
Lena Morén

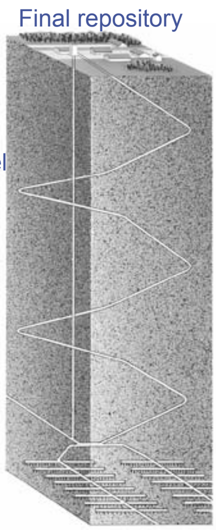
BACKGROUND

SKB's programmes for nuclear waste

- Spent nuclear fuel programme
  – the development of the RMS was initiated within this program
- Loma programme for low and intermediate level waste (both short and long-lived)
  – will apply the RMS developed within the spent nuclear fuel program

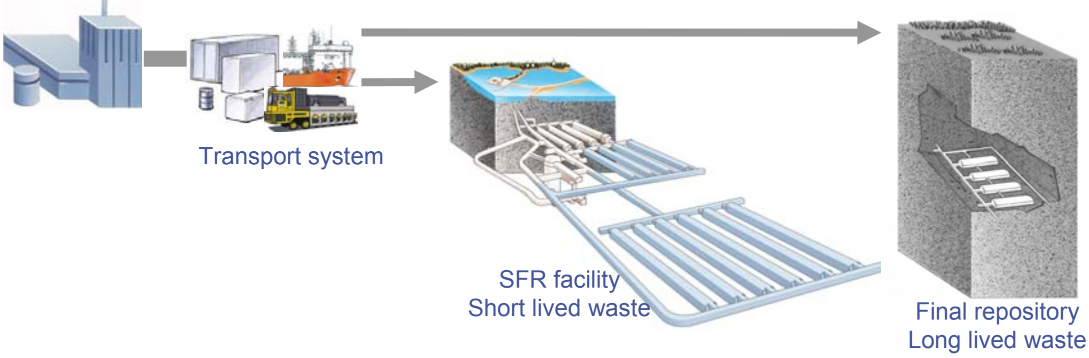
Spent nuclear fuel programme





- Interim storage facility in operation since 1985
- Application for encapsulation plant 2006
  – combined with interim storage facility
- Site for final repository selected in 2009 (Forsmark)
- Application at the end of 2010

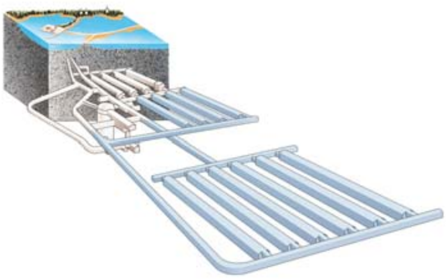
Loma - low and intermediate level waste

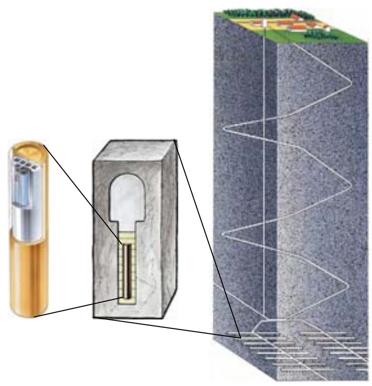


- SFR facility (Forsmark) for short lived waste
  - Licensed for operational waste, in operation since 1988
  - Application for decommissioning waste 2013
- Planning for a repository for long lived low and intermediate level

SKB

Facilities applying RMS





- New part of SFR facility for decommissioning waste
- KBS-3 repository and repository facility (this presentation)

SKB

THE SKB RMS AND ITS STATUS

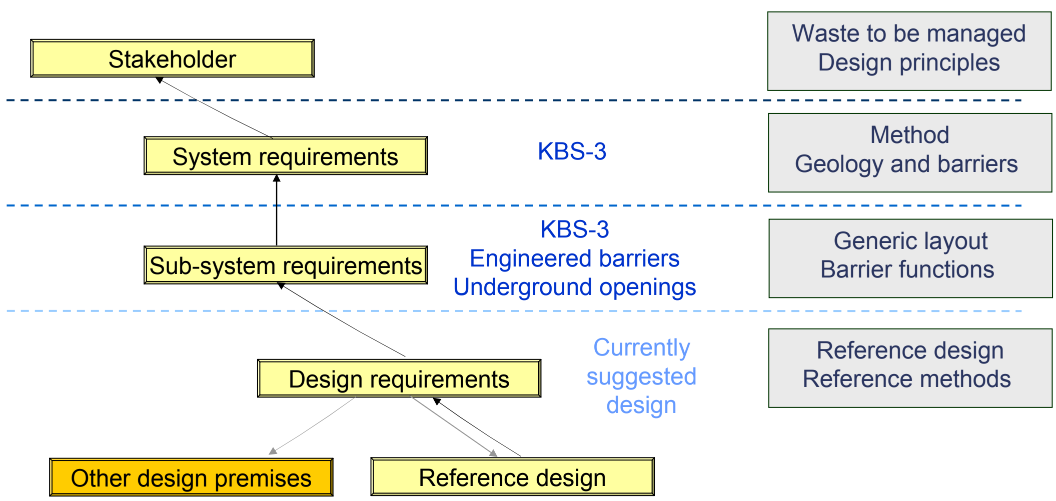
Development of RMS at SKB

- 2001
  - Design premises for the KBS-3 repository compiled in one document
- 2002-2004 Trial project
  - the design premises were transferred to a database
  - the structure of the database was developed
- 2005- ongoing activity
  - requirement management included as an activity within the spent nuclear fuel programme
  - routines for writing and determining design premises developed

Purpose

- Provide correct and complete design premises for the KBS-3 repository and repository facility
- Ensure that the KBS-3 repository and repository facility conforms to the design premises
- Make the basis and motive for the design of the KBS-3 repository and repository facility tracable
- Facilitate system understanding and put details in the design and design work in their context
- Facilitate decission making and avoid mistakes in design, production and operation
- Facilitate development and management

Structure



	Design premises	Sources	Level of detail
Level 1	Objectives and principles	Laws and regulations Stakeholder demands	Problem to be solved Principles to apply
Level 2	Functions of the repository and repository facility	Laws and regulations The spent nuclear fuel The KBS-3 method	KBS-3 repository and repository facility
Level 3	Functions of the barriers and tecnical systems		Engineered barriers Systems in the facility
Level 4	Properties and parameters to be designed	The required functions	Components of barriers and their properties Systems of the facility and thier properties Methods for production
Level 5	Premises for the design	Load cases from the safety assessment Other barriers or parts Production and operation	

Example

Level 1 – The post-closure safety of the final repository shall be based on several barrier functions that are maintained through a system of passive barriers.

Level 2 – The final repository shall contain the spent nuclear fuel and isolate it from the biosphere.

Level 3 –The canister shall withstand the mechanical loads that are expected to occur in the final repository.

Level 4 – Properties that affect the strength of the insert, i.e. the material properties compression yield strength and fracture toughness (K_{1C}) and the dimensions e.g. edge distance, shall be such that the copper shell remains tight with respect to the largest expected isostatic load in the final repository.

Level 5 – An isostatic load of 45 MPa, being the sum of maximum swelling pressure and maximum groundwater pressure.

Requirement attributes

- All levels/kinds of design premises
  - Review status
  - References
  - English translation
- Level 1, 2 and 3 (Stakeholder, system and sub-system)
  - Background
  - Statue, law or regulation
  - Objectives and guidance (only sub-system requirements)
- Level 4 (Design)
  - Decision maker
  - Decision document
  - System number
  - Verification

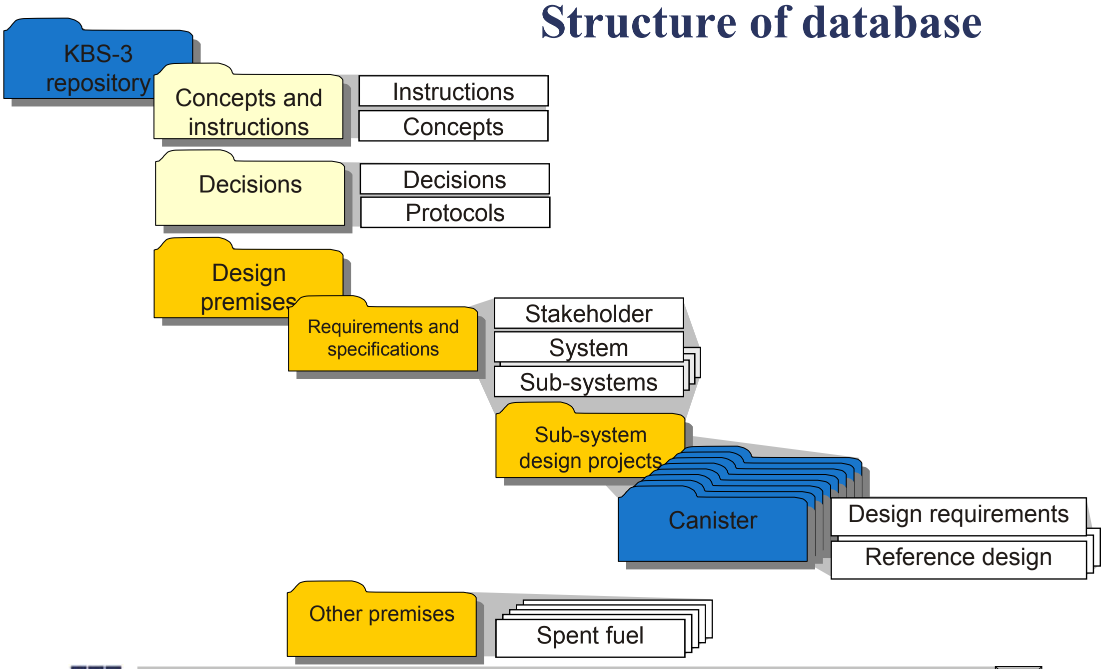
Level 5, other design premises - attributes

- All
  - *pending: project (from a list) within which the premise is used*
- Spent nuclear fuel and systems/parts of the KBS-3 repository and repository facility
  - Specifications of data
  - Other attributes, same as for level 4 requirements
- Design premises from the assessment of the long-term safety
  - document
  - comment and guidelines
- Design premises from the assessment of the operational safety
  - *pending*
- Activities in the facility
  - *pending*

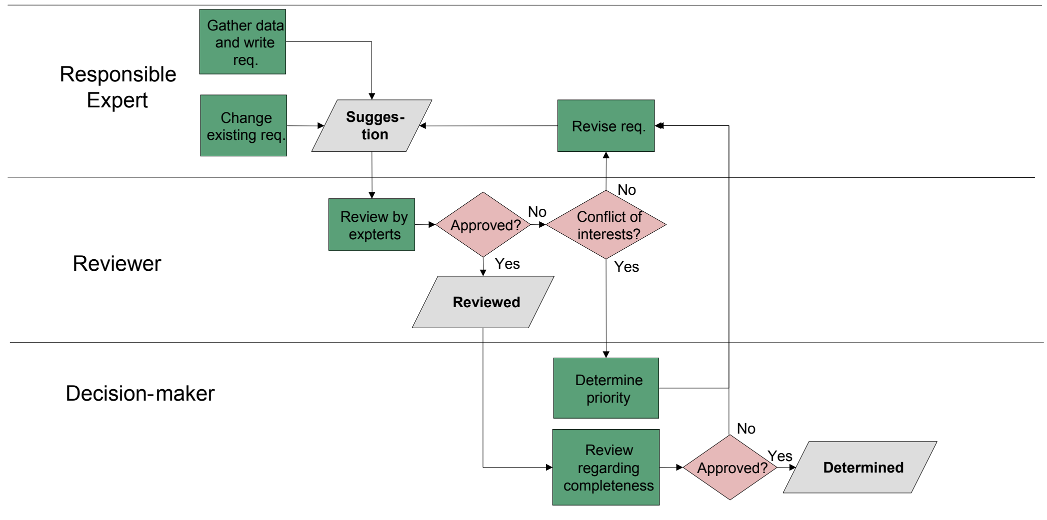
Other information in the database

- Instructions
  - How to create and name projects, folders and modules
  - How to write, reveiw and determine requirements and other design premises and thier attributes
- Links to guiding documents and routines
- Concepts and their definitions
- Decisions
  - Links to project decisions
  - Links to protocols

Structure of database



Write, review and settle requirements



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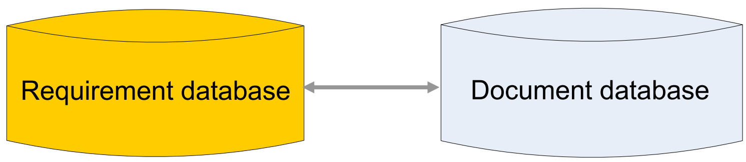
Current status of the database

- Level 1-3
  - Determined versions of all modules with stakeholder, system and sub-system requirements
  - Reviewed by SKB's legal advisors and technical experts
  - Sub-system requirements are currently up-dated
- Level 4 and 5
  - Design requirements for all barriers of the final repository and all systems in the facility – not formally determined
  - Reference design specifications – not formally determined
- Other design premises
  - Determined version of design premises from the long-term safety assessment
  - Specification of spent fuel to be deposited – not formally determined

Development since last meeting

- Organization for writing and determining high level requirements settled
- Routine for technique decisions settled
- High level requirements determined
- First versions of lover level requirements and other design premises in the database
- Projects that shall apply RMS determined – in the next phases of these projects RMS shall be incorporated to the project plans and recourses allocated
- Documents in which the requirements are presented to authorities settled

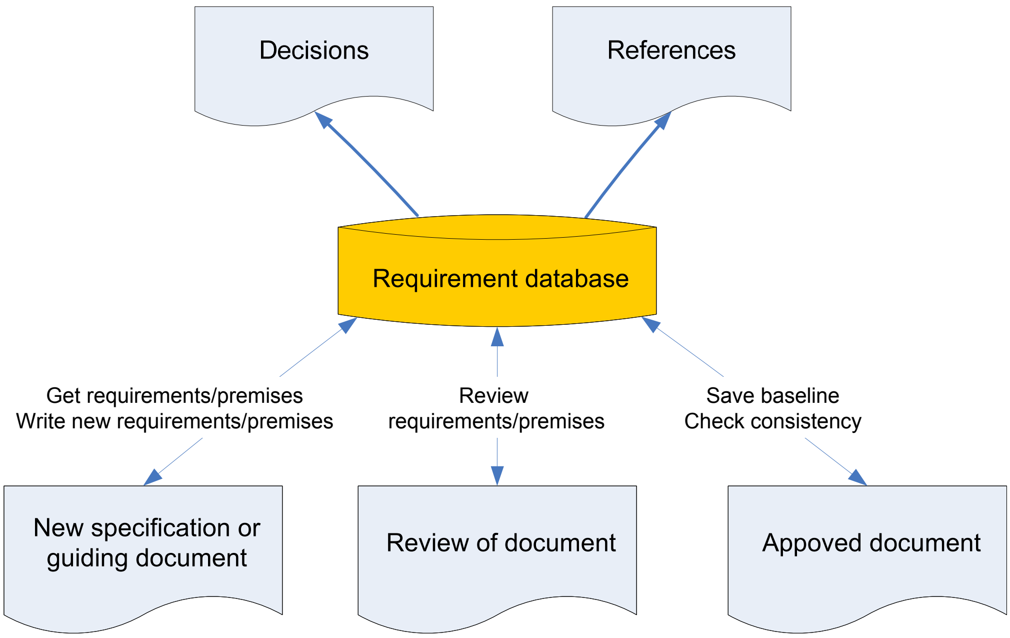
Requirements and documents

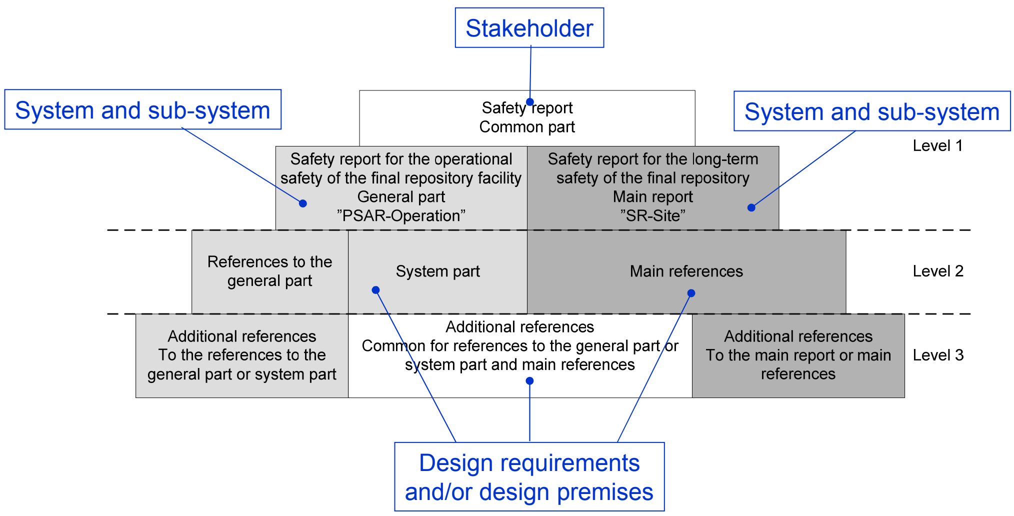


- Relations between different kinds of requirements and design premises
- Links to documents containing requirements and design premises
- Links to decisions and minutes
- Used by SKB as a tool to manage requirements and design premises

- Presentation of requirements and design premises to stakeholders, designers and contractors,
- Explanation and background
- Further instructions

OPEN ISSUES


Decisions
References
Requirement database
Get requirements/premises
Write new requirements/premises
Review
requirements/premises
Save baseline
Check consistency
New specification or guiding document
Review of document
Appoved document



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Information to be included in the database

- Design basis events from the operational safety assessment
- Activities in the facility – the main activities are
  - Rock construction works
  - Deposition works – installation of buffer and backfill, deposition of canister
  - Investigations of the rock
- Verification of the requirements

Open issues

- Verification
  - which information to include
  - how to include the information on the different levels of detail
- Activities
  - links between activiteis and technical systems
  - possibilities to use the information in the database for simulations
- Requirements imposed on the operation of the facility by the engineered barriers and underground openiengs – Operational limits and conditions (STF document)

3. ONDRAF/NIRAS

How ONDRAF/NIRAS approaches RMS Framework & Key Elements

W. Wacquier
Tokyo 26 January 2010

ONDRAF/NIRAS

How ONDRAF/NIRAS approaches RMS Part 1: Framework & Key Elements

- Objectives of the presentation:
  - Give a global overview of the safety and feasibility strategy developed at ONDRAF/NIRAS
  - Provide a description of the safety and feasibility assessment methodologies currently developed to emphasize on the key data (link RMS)

ONDRAF/NIRAS

How ONDRAF/NIRAS approaches RMS Part 1: Framework & Key Elements

- Safety and Feasibility Strategy
- Feasibility Assessment Methodology
- Safety Assessment Methodology
- Conclusions

ONDRAF/NIRAS

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How ONDRAF/NIRAS approaches RMS Part 1: Framework & Key Elements

- Safety and Feasibility Strategy
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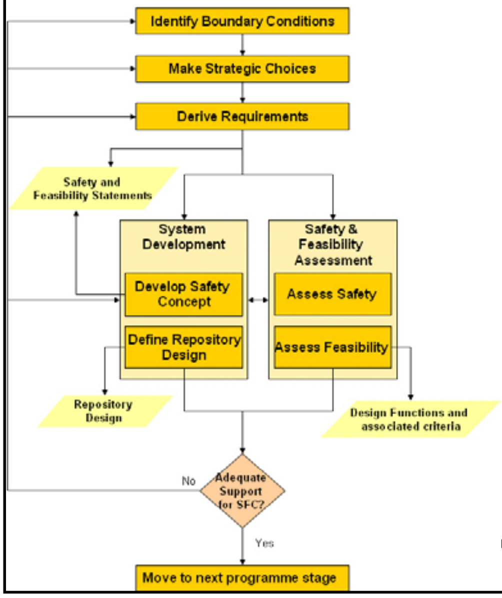
Safety and Feasibility Strategy: iterative process guiding repository development



The Safety and Feasibility Strategy aims to:

- Support development of any Safety and Feasibility Case (SFC) that is to be presented to the authorities at key decision points
- Develop the safety concept and design of a geological repository
- Acquire evidence, through assessments and arguments, to show that the proposed disposal system is safe and feasible

SFC1 planned for 2013

Objective SFC1: Demonstrate that

The disposal system is able to ensure long-term safety while being feasible (no major flaw)

in order to support a « go for siting » decision

Outcomes:

- Description of a reference solution (level of conceptual design)
- Demonstration of its long term safety and its feasibility (substantiation of the safety & feasibility statements)

ONDRAF/NIRAS

Boundary conditions to take into account

ONDRAF/NIRAS Working hypotheses	> Solution on **national** territory > Disposal in **deep geological** formation > Potential HR limited to **argillaceous** formations > Argillaceous formations: **poorly indurated clays** > **Implementation ASAP** (based on waste availability and scientific, technological, societal and economic factors)
International framework	> Conventions & directives (IAEA Safeguard issues) > General texts (ICRP, IAEA, …), …
Belgian and regulatory framework	> Laws (Well-being at work, …) > Royal Decrees (H&S in mines, Prot. ionising rad.) > …
Institutional policy	Recommendations made by competent authorities but not yet in the regulatory framework > AFCN/FANC: Technical Guide Geological Disposal
Other stakeholder conditions	Belgian « non-institutional » stakeholder or foreign institutional stakeholder > Currently no conditions

ONDRAF/NIRAS

The 9 Strategic Choices of ONDRAF/NIRAS

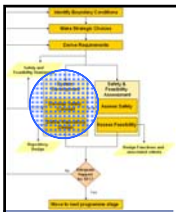
- Boom Clay = **reference**; Ypresian Clay = **alternative**
- Materials & implementation shall **not unduly perturb safety functions**
- EBS designed to provide **complete containment during thermal phase** (heat-generating waste)
- Waste types divided into **groups**, emplaced in separate sections
- **Repository construction and operation ASAP**, but taking due account of scientific, technological, societal and economic considerations
- Disposal galleries, repository sections and repository **closed ASAP**
- Preferences for **permanent shielding** of wastes and **minimisaton of underground operations**
- Preferences for materials & implementation procedures for which **broad experience and knowledge** already exists
- Repository planning shall assume that post-closure surveillance and monitoring will continue for **as long as reasonably possible**

ONDRAF/NIRAS

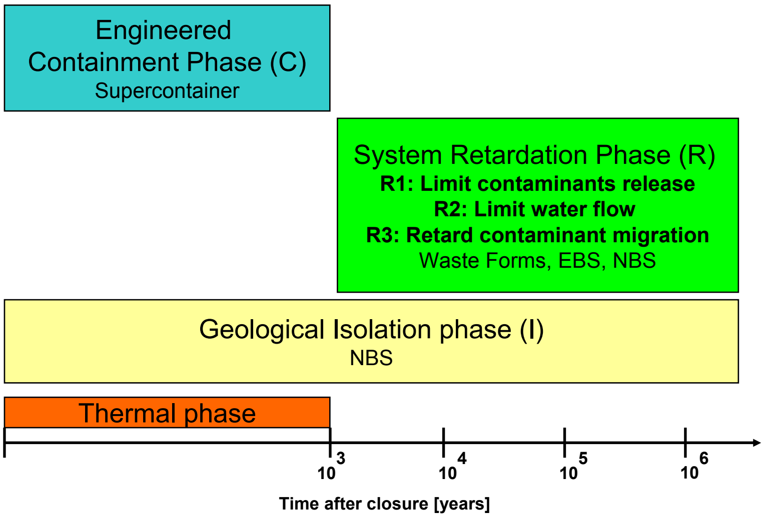
The boundary conditions and strategic choices are translated into requirements

- Requirements are identified in a top-down manner and organised in a structured « tree »
- Top level requirements are expected to be stable
- Requirements = **safety and feasibility statements**
- The statements:
  - ***Definition System Statement***: The proposed disposal system is properly defined (i.e. waste) and its development has been guided by a well-defined and rational step-by-step safety strategy
  - ***Safety Statement***: The proposed disposal system provides passive long-term safety if implemented according to design specifications.
  - ***Feasibility Statement***: The proposed disposal system can be constructed, operated and progressively closed taking into account operational safety issues and with adequate funding
  - ***Uncertainty Statement***: The residual uncertainties related to the proposed disposal system can be adequately dealt with in future programme stages

ONDRAF/NIRAS



System Development - Safety concept
The passive long-term safety elements



ONDRAF/NIRAS

System Development - Repository Design Development as far as is necessary

2010	2013		2020	2025
Confirmation Geol. Disposal	Go for siting	Site(s) selection	Go for licensing	Go for Implementation

SFC 1	SFC 2	...
Conceptual Design	Basic Engineering	Detailed Engineering

Conceptual Design:
> Layout
> Description of facilities & key equipment (functions)
> Material Specification sheets
> Storyboard
> Potential incidental/ accidental situations & mitigation
> Cost assessment

Basic Engineering:
> Layout refined (site)
> System & components further detailed

Detailed Engineering:
Full technical spec. of components

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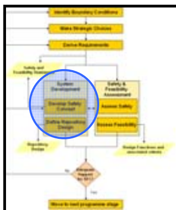


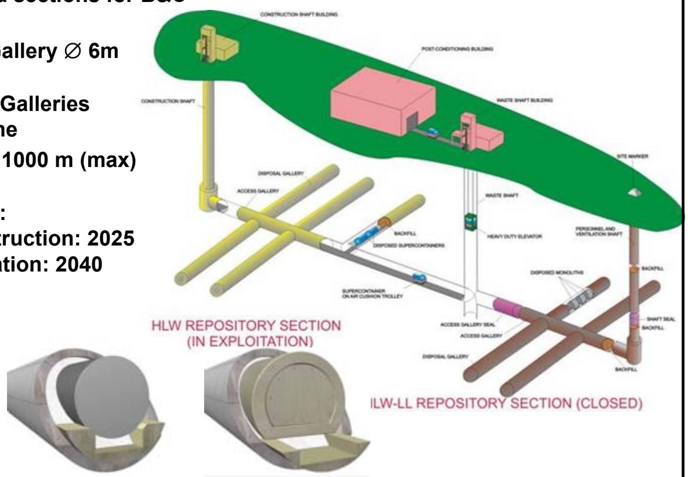
Repository design Current design

Depth: 200 m ("Soft" Clay)
Separated sections for B&C

Access Gallery ∅ 6m

Disposal Galleries
> Fishbone
> ∅ 3m x 1000 m (max)

Schedule:
> Construction: 2025
> Operation: 2040



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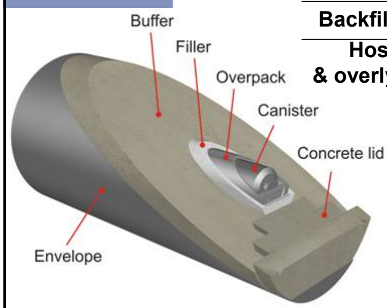
Safety Functions implied by the strategic choices for Supercontainer

Components	LT Safety Functions < Thermal phase	LT Safety Functions > Thermal Phase
Waste Form		R1 (Main)
Overpack	C (Main) - Prevent water contacting the waste	R2 & R3 (Contribute)
Concrete Buffer / Filler	C (Main) - Provide favorable chemical env.	R2 & R3 (Contribute)
Envelope	C (Contribute) – Delay income of water & aggressive species	R2 & R3 (Contribute) – Delay income of water
Backfill & Lining		R2 & R3 (Contribute)
Host Rock & overlying layers	I (Main)	I (Main) R2 & R3 (Main)



How ONDRAF/NIRAS approaches RMS Tokyo 25-27 January 2010

How ONDRAF/NIRAS approaches RMS Part 1: Framework & Key Elements

- Safety and Feasibility Strategy
- Feasibility Assessment Methodology
- Safety Assessment Methodology
- Conclusions

ONDRAF/NIRAS

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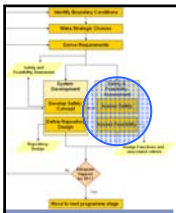

Feasibility Assessment Methodology

- Objectives:
  - Identify potential remaining uncertainties
  - Define and prioritise B&C feasibility programme
  - Present a reference solution
  - Defend the reference solution by supporting the Feasibility Statements by strong arguments in order to demonstrate that is technologically (Engineering & Op. Safety) and economically feasible to construct, operate and close a repository (i.e. no major flaw)

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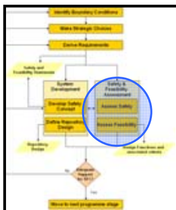
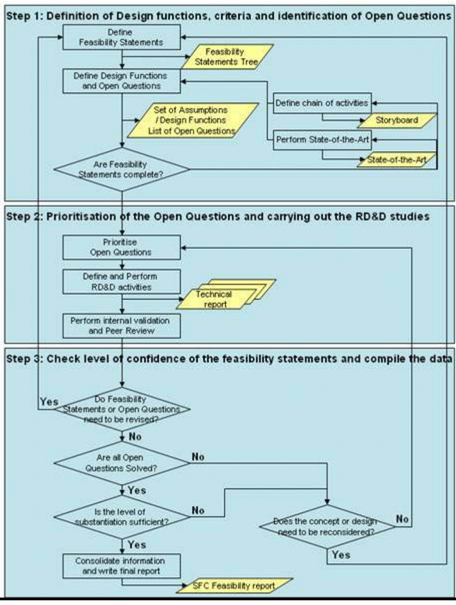


Feasibility Assessment Methodology: Iterative process structured in 3 steps



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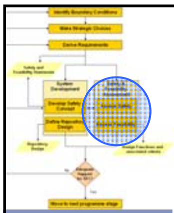
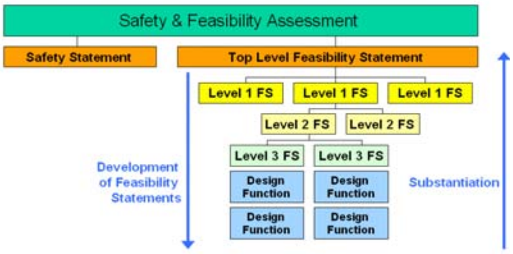


Step 1 - Functions, Criteria & Open Questions

> Statements to demonstrate feasibility

Feasibility Statements (equivalent to requirements):

> organise in a tree structure
> derive from safety concept in a top-down approach
> cover all activities (removal primary package -> institutional control)



Design Function:

> identify for lowest level of the feasibility statements
> caracterised by criteria allowing to:
- evaluate if the feasibility statement (requirement) will be met
- identify potential open questions
- specify a specific design (ref. or variants)

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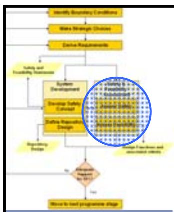

Step 1 - Functions, Criteria & Open Questions

> Top levels statements

FS The proposed disposal system can be constructed, operated and progressively closed taking into account operational safety issues and with adequate funding

FS 1 The assessment basis and feasibility assessment provide evidence of the engineering practicality of the proposed disposal system	**FS 2 Health & Safety and Environmental issues, as evaluated in feasibility assessment, can be mastered, taking into acccount all relevant uncertainties**	**FS 3 The costs for the construction, operation and closure of the repositoy, as calculated in feasibility assessment, can be covered with adequate funding**	**FS 4 Quality assurance procedures have been applied that favour confidence in assessment basis development and in the findings of feasibility assessment**

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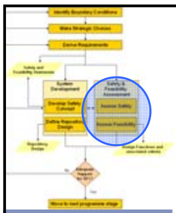

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Step 1 - Functions, Criteria & Open Questions
> Identification of design function

Feasibility Statement
> Feasibility Statement

Design Function / Subfunction
> Design Function
> Description
> Type

Criteria
> Criteria
> Requested Level
> Design Type
  - Reference Design
  - Variant Design
> Flexibility
> Current Level
> Validation Mode
> Argumentation
> Dependencies
> Conflicts

Open Question
> Open Question
> Priority
  - Impact on Safety Concept
  - Level of uncertainty
  - Justification
  - Priority
> Way Forward
  - Who
  - How
  - When
> Status

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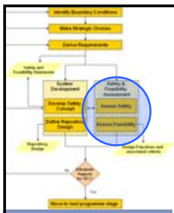
Step 1 - Functions, Criteria & Open Questions
> Completeness check

- *Storyboard* (chain of events):
  - identify if no steps/activities are missing
  - identify if all significant open questions are identified
  - help to clarify and take assumptions
  - Set of information:
    - ***Step*** – Which action is performed? (e.g. retrieval of primary waste package)
    - ***Equipment* or *system*** – How is the action performed? (e.g. truck, tilting system)
    - ***Location*** – Where is the action performed? (e.g. reception hall)
    - ***Next step*** – What is the next action?
    - ***Time*** – How long does the action last?
    - Possible incidents/accidents – ***What if*** scenarios
    - Measures for ***quality control***
    - The link with ***design functions***
- *state-of-the-art* (relevant best proven practices)



Step 2 – Prioritisation

Prioritise Open Questions & Define R&D studies

Potential impact on safety concept		
High impact	***Priority Medium*** Reduce Uncertainties	***Priority High*** ***Focus for SFC-1*** Define R&D Programme
Low impact	***Priority Low*** Optimise the Design	***Priority Medium*** Identify most appropriate alternative
	Low **(High confidence)**	**High** **(Important doubt)**

Level of uncertainty to solve the issue

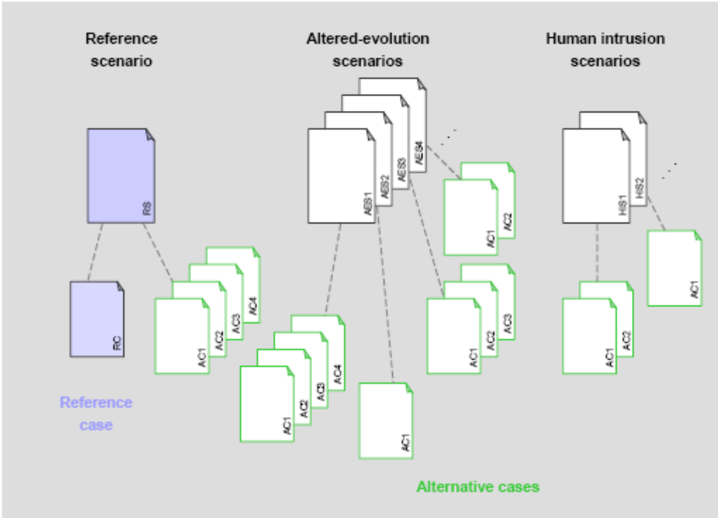
ONDRAF/NIRAS

How ONDRAF/NIRAS approaches RMS
Part 1: Framework & Key Elements

- Safety and Feasibility Strategy
- Feasibility Assessment Methodology
- Safety Assessment Methodology
- Conclusions

ONDRAF/NIRAS

Safety Assessment methodology
Development of scenarios & ass. cases



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Safety Assessment methodology
Data governing evolution of system

- Diversity of data representing safety statements governing evolution of disposal system given in the form of
  - Source range = basic range outside of which parameter value is unlikely to lie (min, max, (pdf))
  - Expert range = realistic range within which parameter value is expected to lie (min, max, (pdf), best estimate)
  - Considering phenomenological uncertainties
    - Upscaling (lab to in-situ)
    - Evolving conditions (e.g. climate evolution, volcanism)
    - Transferability (applicability in a larger zone)
- A data clearance process will be developed to « freeze » data for safety assessment (traceability)
- Treatment of other uncertainties (model, scenario) is under discussion

ONDRAF/NIRAS

How ONDRAF/NIRAS approaches RMS Part 1: Framework & Key Elements

- Safety and Feasibility Strategy
- Feasibility Assessment Methodology
- Safety Assessment Methodology
- Conclusions

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Conclusions

- Safety and Feasibility assessment methodologies developed based on the strategy
- Requirements are managed through the safety and feasibility statements
- In the Feasibility assessment methodology, statements are further derived into functions and associated criteria to demonstrate the feasibility

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4. POSIVA

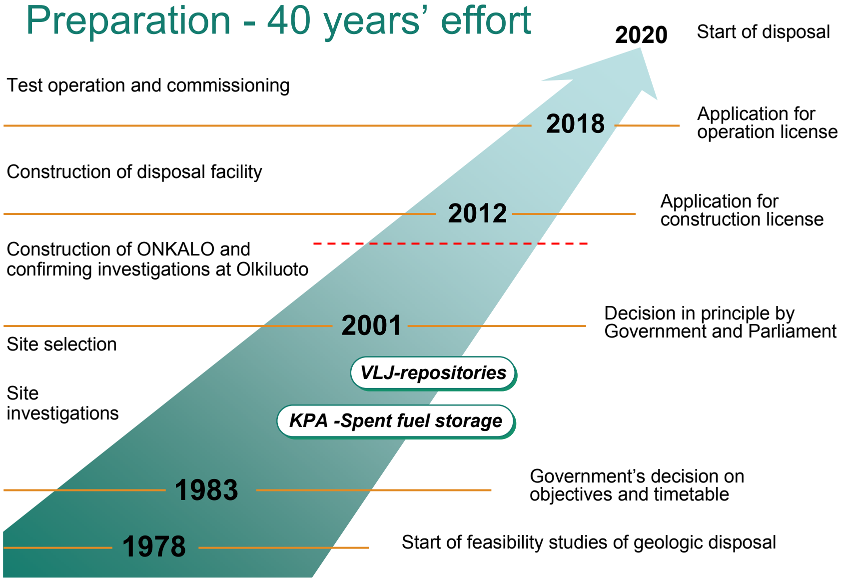
Requirements Management System in Posiva

Status, Open Issues and Future Plans

Tiina Jalonen

POSIVA

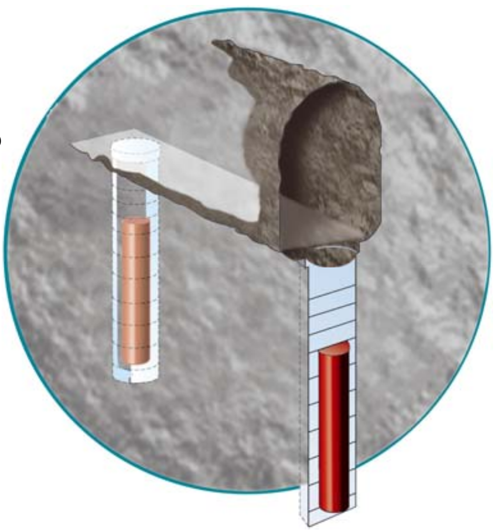
Preparation - 40 years' effort



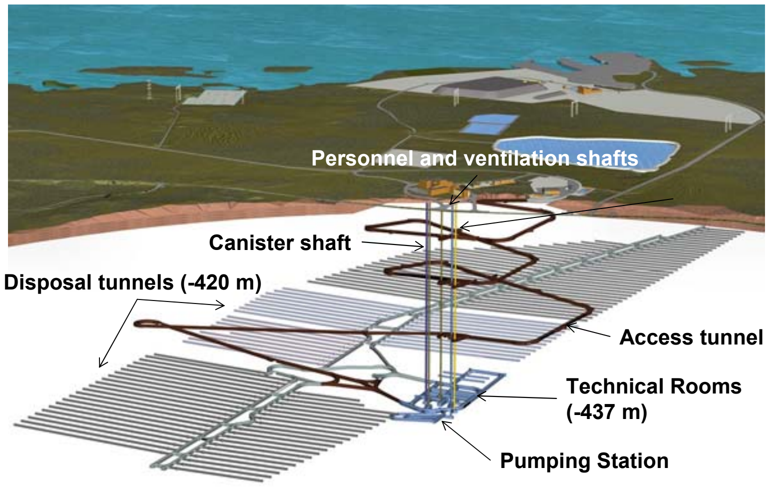
Background
Long-term Isolation from the Nature (KBS-3)

Background
Multibarrier principle

- The flow rate of the groundwater in bedrock is minor and slow.
- The groundwater found deep in the bedrock contains no oxygen and has no impact on copper.
- The backfill material expands and prevents any water movement around the container.
- The stone type of the final repository almost completely prevents water movement, and thus all the material will virtually stay in their place in the bedrock.



Deep repository



Posiva's RMS Project

- The objective of the project has been to design, implement and introduce a **systematic process** and an **information system** to manage the requirements related to the geological disposal of spent nuclear fuel in Finland.

Objectives 1/2

- The desired result of the project is an information system with a database which
  - Includes all the significant requirements, the reasoning underlying them, and the existing specifications to fulfil them
  - Enables an easy review of compliance between separate specifications and requirements

POSIVA Tiina Jalonen 7

Objectives 2/2

- The desired result of the project is an information system with a database which
  - Contains information of dependencies between requirements
  - Enables a systematic review and documentation of influence derived from alterations in requirements
  - Enables implementation of requirements management as part of day-to-day operations within organisation

POSIVA Tiina Jalonen 8

Developing the RMS

- The project and the project group were set up in 2006
  - The project group consists of the project manager Juhani Palmu and representatives from different areas – disposal plant design, long-term safety, ONKALO construction and safety/quality control
- The software system was evaluated and selected
  - **DOORS** (Telelogic)
- Co-operation & consulting partner was selected
  - (Eurostep Oy)
- The structure and the contents were defined (3rd Qtr, 2007)

System Structure

Level 1 - Stakeholder requirements - Legislation, decisions by the parliament, guides, owners

Level 2 - System requirements - The KBS-3 concept

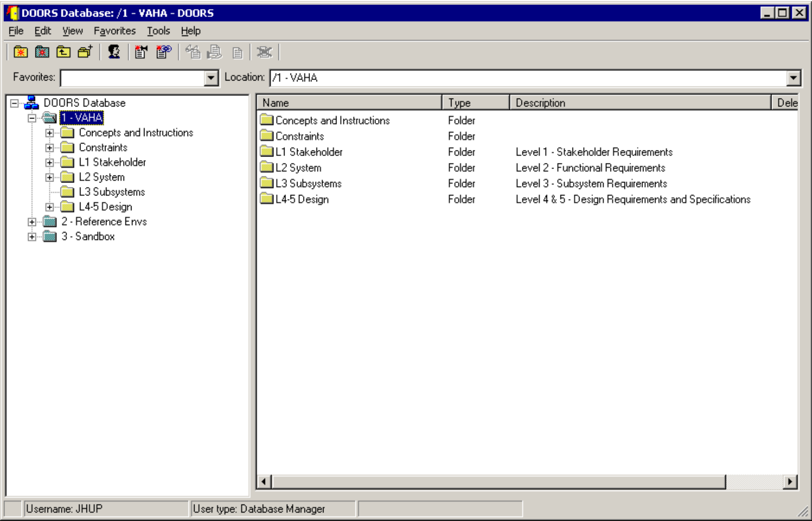
Level 3 - Sub-system requirements - The role of the key KBS-3 components

Level 4 - Design requirements - Detailed design req. of the key components

Level 5 - Design specifications - Reference design

Constraints - Things that can't be designed/changed like the site properties (salinity etc.)

System Structure – a view of the Database



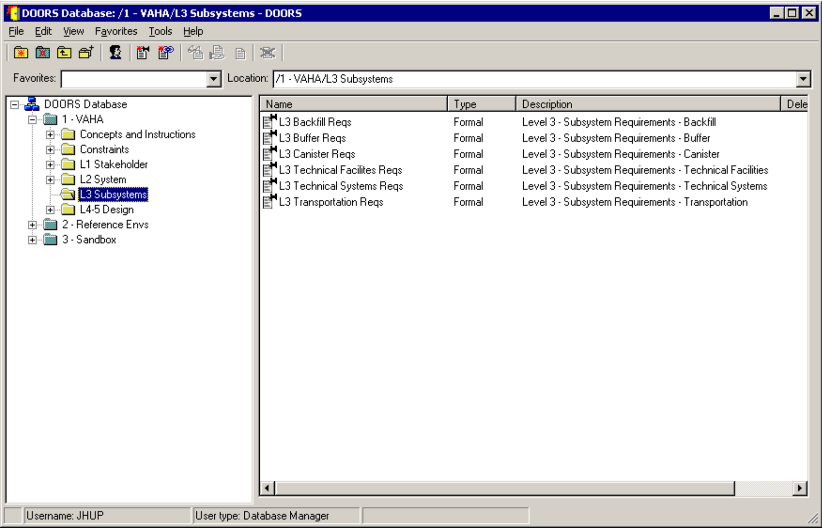
VAHA – Vaatimusten Hallinta – Requirements Management

Defining the requirements 1/2

- The project team gathered the Stakeholder requirements (L1) and the System requirements (L2) 3rd Qtr 2007
- A person responsible for gathering the requirements for each sub-system (L3) was nominated
  - Canister – Tiina Jalonen, Development manager
  - Buffer – Keijo Haapala, Development engineer
  - Backfill & Closure – Johanna Hansen, Development Coordinator
  - Technical facilities – Petteri Vuorio, Design engineer
  - Technical systems – Pasi Mäkelä, Design engineer

VAHA – Implementation with Doors

VAHA ≈ Vaatimusten Hallinta – Requirements Management



Defining the requirements 2/2

- Gathering existing requirements for levels 3-5 in each sub-system group was done during 2007
- 10/2007 =>: Specifying the structure and the contents and defining dependencies for the requirements management system

Status 1/2

- Current status: appr. 1500 requirements and specifications gathered
- The following requirements have been compiled and approved in the system
  - stakeholder requirements
  - system requirements
  - sub-system requirements
    - canister sub-system requirements (L3) and design requirements (L4)
    - backfill sub-system requirements (L3) and design requirements (L4)
- The buffer requirements have been compiled but no consensus has been reached in the approval process

Status 2/2

- Doors Web Access (DWA) was launched into production in January 2009. The new system will enable external parties (consultants and the Finnish regulatory authority STUK) to access the RMS system remotely

VAHA – Doors Web Access (DWA)

- https://rms.posiva.fi/dwa
- access with the SecurID authentication key delivered by Posiva & TVO

Open issues

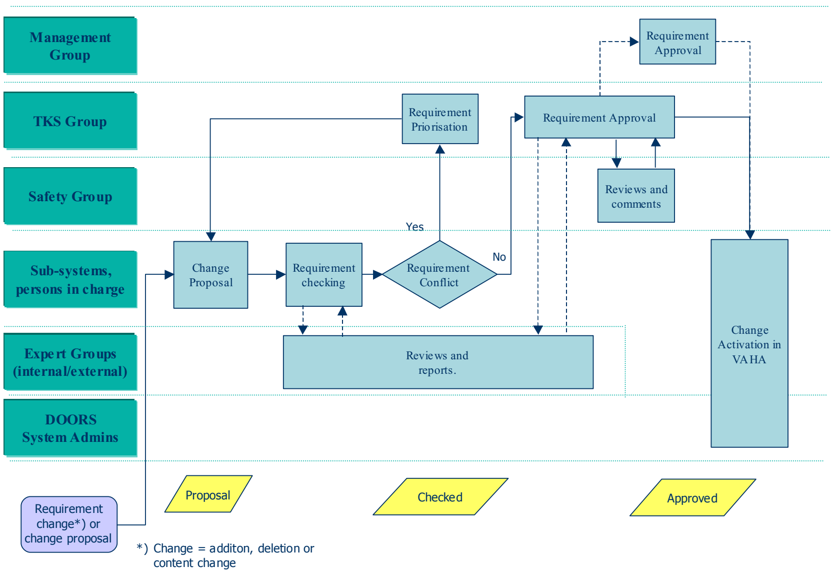
- The sub-system requirements that have been compiled but need to be re-organised and approved
- Technical facilities
- Technical systems
- new sub-systems Transportations and Operations

- Actual verification of the requirements and specifications
- Some demonstrations done, some planned

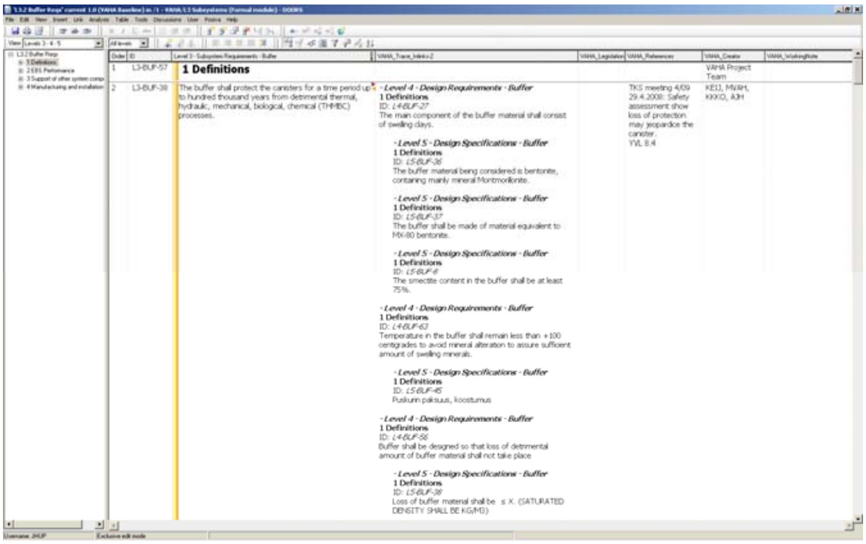
Future plans

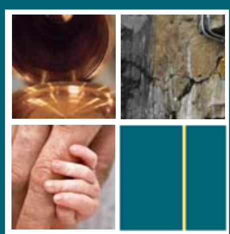
- The existing sub-system requirements will be linked (connections defined) and specifications will be added
- Organisational issue: the Posiva Safety Unit will be the owner of the RMS in future
- The change management process will be rehearsed

VAHA Change Management Process



Traceability Views





POSIVA

5. Nagra

Requirements management at Nagra

(Day 1 – Session 2)

January 2010

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Background - The Swiss Waste Management Programme

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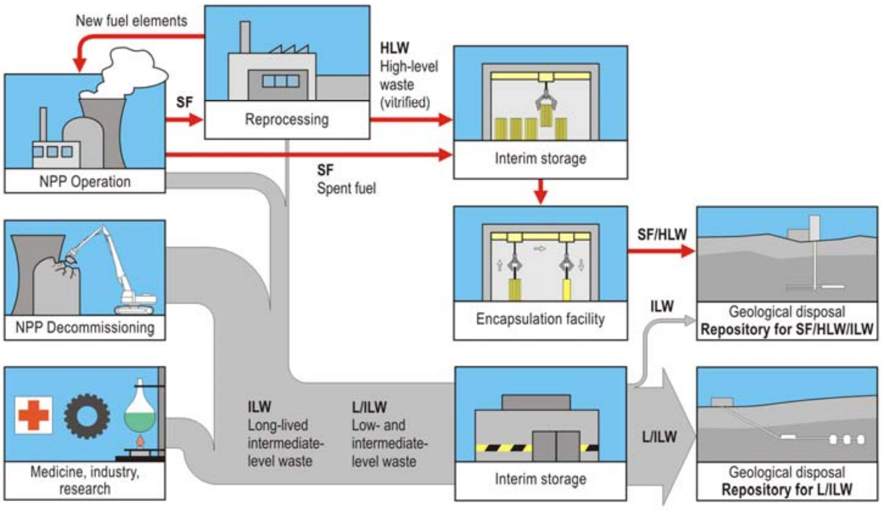
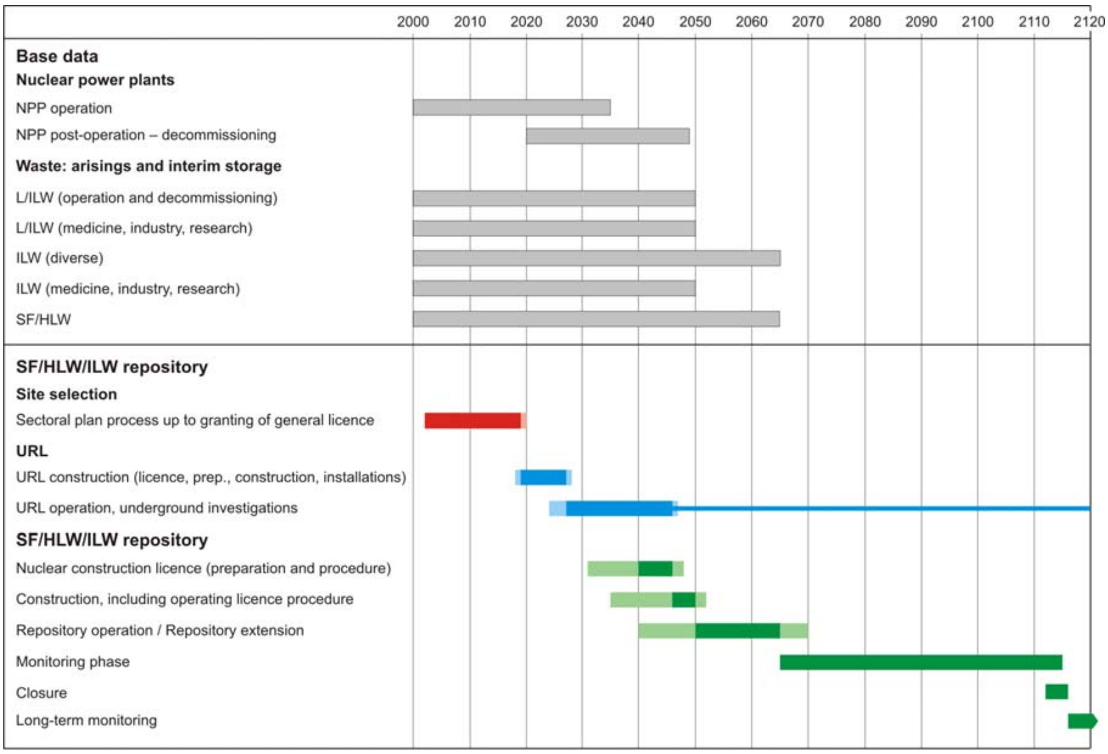
Swiss waste management concept



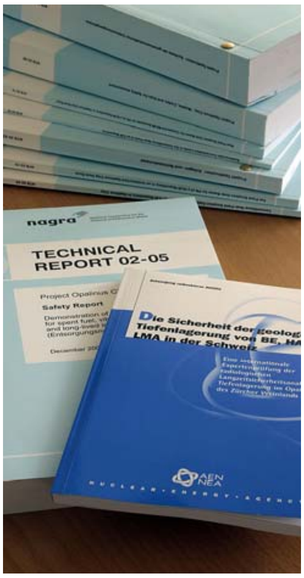
Two repositories:

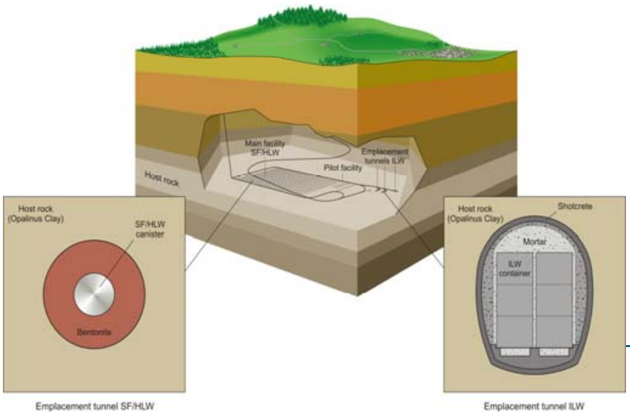
- Spent Fuel (SF), vitrified high level waste (HLW) ➔ HLW repository
- Long-lived intermediate waste (ILW/TRU) ➔ HLW repository (co-disposal)
- Low and intermediate waste (L/ILW) ➔ L/ILW repository

Time schedule for repository for SF/HLW/LL-ILW



HLW-repository: Project Opalinus Clay (Zürcher Weinland)





a solid basis

nagra

30 years of research and development

- **the scientific-technological basis** is available and accepted
- **the inventory of possible host rocks in Switzerland** has been evaluated
- **the demonstration of disposal feasibility** for HLW repository for Opalinuston in Zürcher Weinland has been **accepted** in 2006 **by federal government**
  (for L/ILW: already accepted in 1988)
- important **strategic decisions** have been taken

→ How to implement has been clarified
The scientific basis is available and accepted

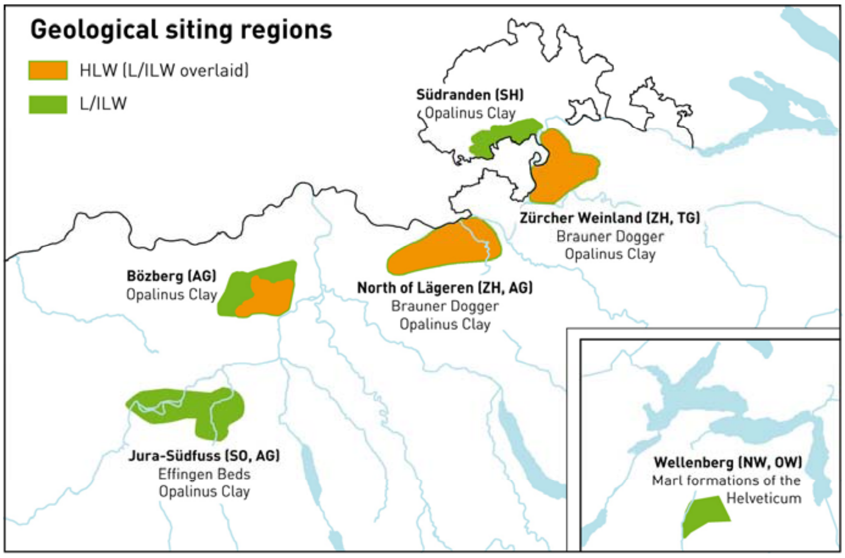
Now: where to implement?

A stepwise site selection procedure

Sectoral Plan 'Geological Repositories' (land use planning law)

- **Part 1: Development of concept (- 2008)**
  - Aims, boundary conditions
  - Procedure (steps, role/responsibilities of stakeholders, products)
  - Criteria (safety/feasibility, land use planning, socio-economic issues)
- **Part 2: Implementation (2008 - ~ 2016?)**
  - **1st stage (2.5 a)**: identification of potential regions (long-term safety & engineering feasibility → geology)
  - **2nd stage (2.5 a)**: within potential regions: identification of sites (land use planning, environmental impact, … → surface infrastructure, provisional safety analyses) & selection of 2 sites for more detailed evaluation
  - **3rd stage (2.5 – 4.5 a)**: field investigations, selection of 1 site → general licence (as part of nuclear energy law)

Proposed siting regions



- are result of systematic application of requirements **of Sectoral Plan**
- do consider the geological possibilities of the **whole of Switzerland**
- are derived in a systematic, step-wise narrowing-in process **based on safety and engineering feasibility**

Requirements management at Nagra

nagra.

Goals for Nagra's requirements management system

Major goals

- Nagra wants to have a complete overview on all relevant requirements (compilation of requirements)
- For each of the issues at hand, Nagra has to ensure that all relevant requirements are considered (specification of requirements)

Operational goals

- Facilitate repository development (incl. transparency for communication with stakeholders)
- Facilitate decision making (clarify objectives)
- Ensure traceability of decisions (motivation for decisions)
- Ensures continuously updated basis (and helps keeping track of changes)

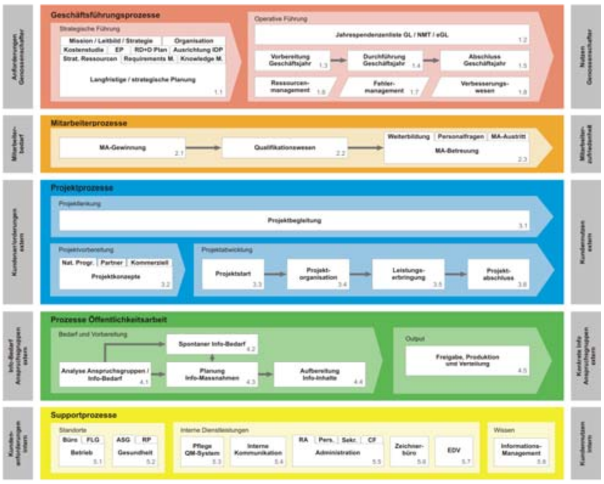
Thus, the requirements management system …

- … has to contribute to ensuring safe repositories
- … should provide confidence to the stakeholders involved (Nagra, other)

Framework

- Origin of requirements → compilation of information
  - Laws, ordinances, regulatory guidelines, stipulations,…
  - Instructions by owners of Nagra (NPPs, Federal office of health)
  - Science & technology
  - Authorities' expectations (recommendations, …)
  - Expectations from scientific community & public
- Using requirements → specifications & information for …
  - „Hardware“
    - Facility design
    - Development of engineered barriers
  - Planning of field investigations
  - Documents for decision-points, licensing
  - Development & update of RD+D programme
  - Development & update of waste management programme
  - Update of cost study
  - Consultation on revisions of laws, ordinances, regulatory guidelines, etc.
  - …

Requirements Management is part of Nagra's (Q)MS



- Is part of strategic planning (formal process) with periodic check-points
- Has direct links to projects (input to development of project specifications / boundary conditions for project)

… is also part of (formal) interaction with authorities

- The different steps: proposal by Nagra → presentation / discussion with authorities → finalisation
  - Definition of **requirements & boundary conditions** (linked to overall objectives)
  - Development of alternatives, incl. justification
  - Selection of alternatives to be developed in more detail, incl. justification
  - Evaluation of alternatives

Basic structure of Nagra's RMS

1 For which reason?
- Laws, ordinances, regulatory guidelines, stipulations
- Instructions by owners of Nagra
- Science & technology
- Authorities' expectations
- Expectations from scientific community & public

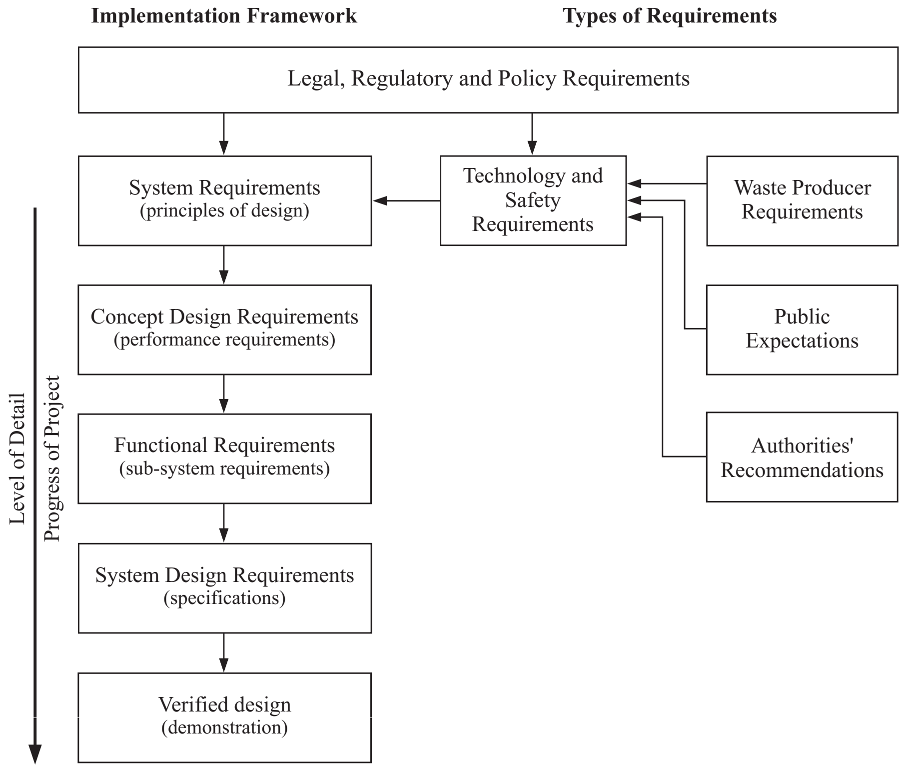
2 What requirement? (hierarchical structure)
- Aim / purpose: Principles & functional requirement for all stages in life-cycle
- Relevant system-properties that enable fulfilment of principles & functional requirements and specific requirements (for all stages in repository life-cycle)
- Specifications (layout, material, processes)

3 For which element? (hierarchical structure)
- Waste management concept
- Repository concept (for all stages in life-cycle)
- Concept for HLW & L/ILW repositories
- Geological barrier (incl. geological situation); engineered barriers; detailed components

4 When?
- When (and at what level of detail) must compliance with requirement be reached?

5 For which (alternative) system?

Information flow in Nagra's RMS



Hierarchical structure of requirements (I)

2 What requirement?

2.1 Identify principles and functional requirements (objective/motivation)

2.1.1 Waste management programme

2.1.2 Long-term safety

2.1.3 Engineering feasibility (construction, operation, closure)

2.2 For the various system elements / components (see 3): Identify properties (→ indicators) that contribute to fulfilment of principles and functional requirements

2.3 Define requirements for these properties to ensure effectiveness of elements / components

2.4 Define specification for system elements / components, so that requirements are fulfilled

p.m.: associated attributes

- type of requirement (limit, target, optimisation, issue)
- level of detail for demonstration (concept, …, detailed demonstration)
- milestone for fulfilment of requirement
- etc.

Hierarchical structure of requirements (II)

3 *For which element?*

3.1 Waste management concept (wastes, time plans, types of repositories, …)

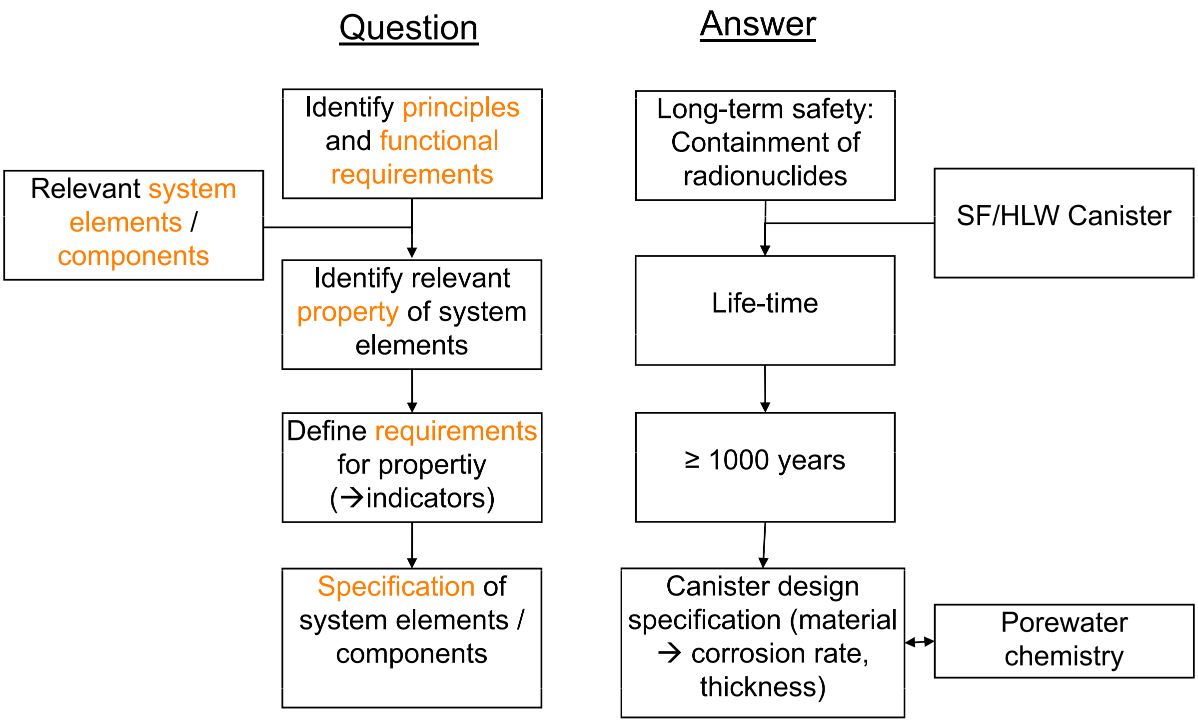
3.2 General repository concept (relevant to all types of repositories)

3.3 HLW repository
- The different elements / components of repository (hierarchical)
- For the different phases of the repository (construction, operation, closure, post-closure)

3.4 L/ILW repository
- (details as in 3.3)

3.5 Combined HLW & L/ILW repository
- (details as in 3.3)

Example



Requirements Management: Status

- Requirements Management is a process within Nagra‘s (quality) management system since several years
- Requirements Management has been used in several key projects (→ formal reports), especially:
  - Wellenberg site investigation (1997-2000)
  - Waste management programme (2006-2008)
  - Site selection process: proposal of siting regions (2003-2008, continuing)
- Structure & process of requirements management has developed (evolutionary process, still changing); development will continue
- Requirements documented in several external reports and internal databases (File Maker Pro, EXCEL, …)
- IRQA has recently been chosen as standard software (based on structured evaluation process)

Conclusions

- Requirements Management is a process to derive and apply requirements → consideration of overall objectives & overall context is important)
- Requirements Management is part of the organisation's culture: It serves to define objectives, helps to evaluate whether objectives are met and does this in a traceable manner to make the quality visible
- This requires anchoring the RMS within the management system of the whole company & its consistent application in all important projects
- A broad and appropriate structure of the RMS with emphasis on the broad objectives is of key importance
- The major difficulty encountered up to now is related to the documentation of requirements

  Presently, the requirements are stored in more than one database – while their underlying scientific basis is documented in several formal reports

Thank you!

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6. JAEA

JAEA KMS
Overview, Knowledge Base and KM Toolkit

RMS Status and Recent Developments
Information Exchange Meeting
Tokyo, Japan
26 January 2010

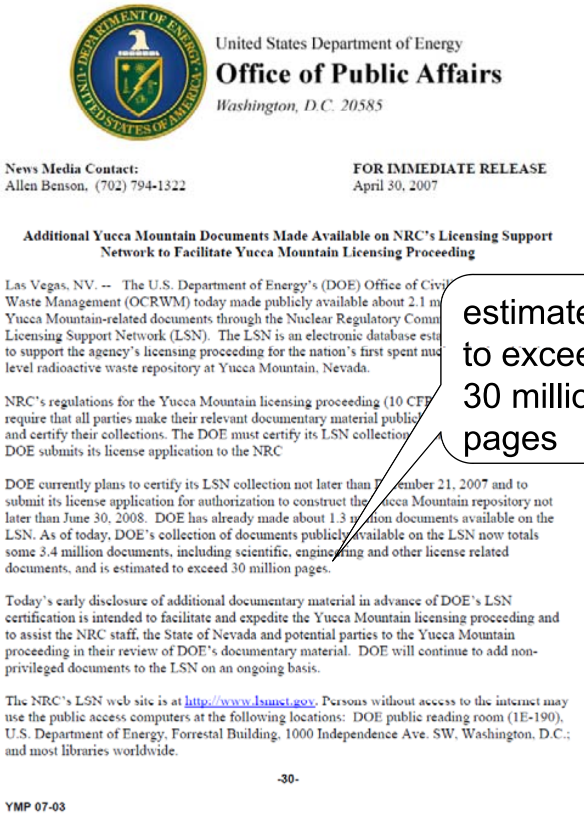
K.Hioki, H.Osawa, T.Semba, H.Makino
Knowledge Management Group
Japan Atomic Energy Agency

Advanced KM is a requirement not a luxury

- Total inventories and rates of production of information and data are continuing to expand exponentially: processed knowledge is failing to keep up
- Traditional management systems have failed completely...

  ...but resulting lack of overview means that this has not been recognised in many cases

The Yucca Mountain Project



United States Department of Energy

Office of Public Affairs

Washington, D.C. 20585

News Media Contact:
Allen Benson, (702) 794-1322

FOR IMMEDIATE RELEASE
April 30, 2007

Additional Yucca Mountain Documents Made Available on NRC's Licensing Support Network to Facilitate Yucca Mountain Licensing Proceeding

Las Vegas, NV. -- The U.S. Department of Energy's (DOE) Office of Civi
Waste Management (OCRWM) today made publicly available about 2.1 m
Yucca Mountain-related documents through the Nuclear Regulatory Comn
Licensing Support Network (LSN). The LSN is an electronic database esta
to support the agency's licensing proceeding for the nation's first spent nuc
level radioactive waste repository at Yucca Mountain, Nevada.

NRC's regulations for the Yucca Mountain licensing proceeding (10 CFR
require that all parties make their relevant documentary material public
and certify their collections. The DOE must certify its LSN collection
DOE submits its license application to the NRC

DOE currently plans to certify its LSN collection not later than D ember 21, 2007 and to submit its license application for authorization to construct the ucca Mountain repository not later than June 30, 2008. DOE has already made about 1.3 m lion documents available on the LSN. As of today, DOE's collection of documents publicly available on the LSN now totals some 3.4 million documents, including scientific, engineering and other license related documents, and is estimated to exceed 30 million pages.

Today's early disclosure of additional documentary material in advance of DOE's LSN certification is intended to facilitate and expedite the Yucca Mountain licensing proceeding and to assist the NRC staff, the State of Nevada and potential parties to the Yucca Mountain proceeding in their review of DOE's documentary material. DOE will continue to add non-privileged documents to the LSN on an ongoing basis.

The NRC's LSN web site is at http://www.lsnnet.gov. Persons without access to the internet may use the public access computers at the following locations: DOE public reading room (1E-190), U.S. Department of Energy, Forrestal Building, 1000 Independence Ave. SW, Washington, D.C.; and most libraries worldwide.

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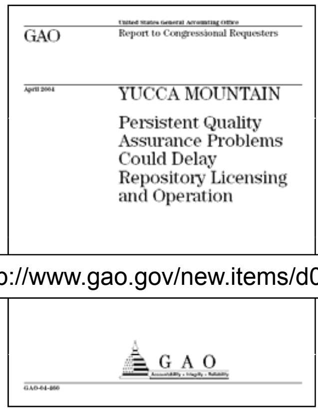
YMP 07-03



GAO

Report to Congressional Requesters

YUCCA MOUNTAIN

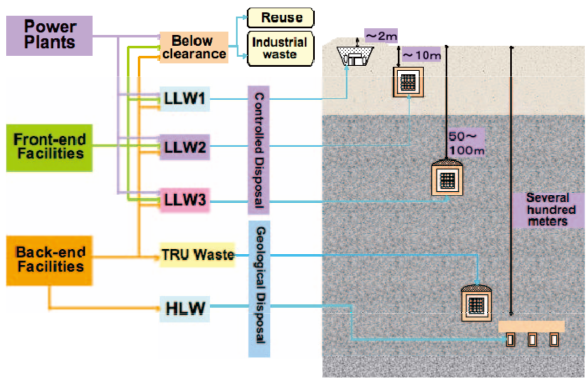
Persistent Quality Assurance Problems Could Delay Repository Licensing and Operation

G A O

http://www.gao.gov/new.items/d04460.pdf

In Japan, major projects running in parallel...

- Near-surface facilities operating at Rokkasho and interim-depth repository for higher activity waste in preparation for licensing
- Deep repositories for HLW & TRU waste to be implemented following response to call for volunteers
- Integrated concept for industrial and research wastes in development
- Extensive supporting R&D, including 2 URLs



Overview of facilities for wastes from nuclear power production

...with a limited (and aging) work force

- Over the last 2 decades, key integration and overview tasks have been carried out by teams whose experience has grown over that period

  ...these are now completely overloaded

  ...and most experienced members are nearing retirement

Geological disposal (HLW/TRU waste) timeline

H3 (1991)	H12 (2000)	H17 (2004)	H22 (2009)	Licensing (2030s)

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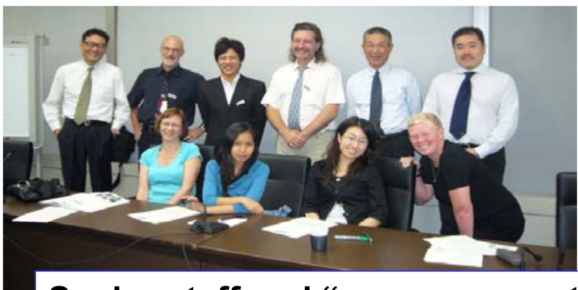
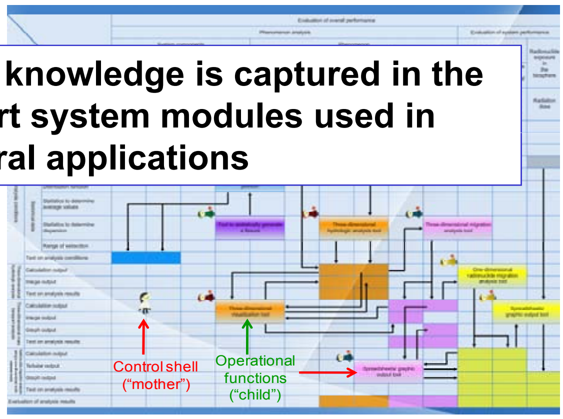
Management of tacit knowledge

Recognised to be a critical resource, which is captured using both training methods (both traditional and advanced) and knowledge acquisition and capture within expert systems

19 Japanese organisations are members of the ITC



Senior staff and "young generation" work together in training courses and brainstorming exercises



Tacit knowledge is captured in the expert system modules used in several applications

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KMS development: background

- From a review of international experience (also outside the radwaste business), major problems with developing and implementing advanced KMS tools were identified as:
  - establishing communication between KE system designers (IT experts) and knowledge producers / users (extremely diverse, multidisciplinary)
  - Insufficient use of capabilities of modern computing systems

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KMS development: approach

- Specifically to address the identified concerns:
  - radwaste generalists learned to use KE tools and took over the job of KM system design (with support of IT experts only where needed)
  - recent advances in computing systems (hard- & software) were fully utilised and component systems were continually tested for applicability and user-friendliness
  - tools facilitate dialogue with users and feedback serves to drive further improvement and tailoring to specific needs

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KMS development process

- Despite initial scepticism, the JAEA approach has resulted in development of a KMS which is increasingly accepted throughout the Japanese programme:
  - the KMS team are capable of communicating with all knowledge producers and users
  - development focuses on benefits to all involved, as this is the key to acceptance
  - tools are being tested by user groups and made available as soon as possible

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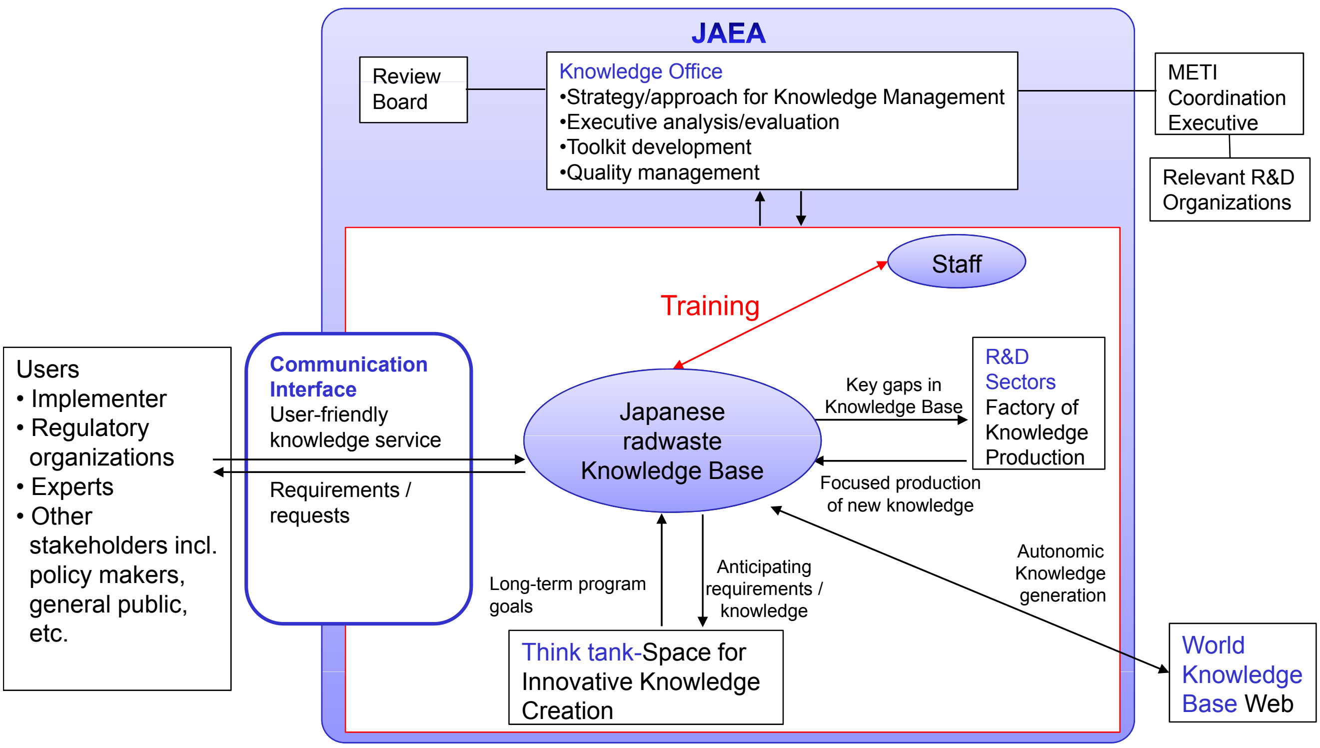
Structure and components of the KMS



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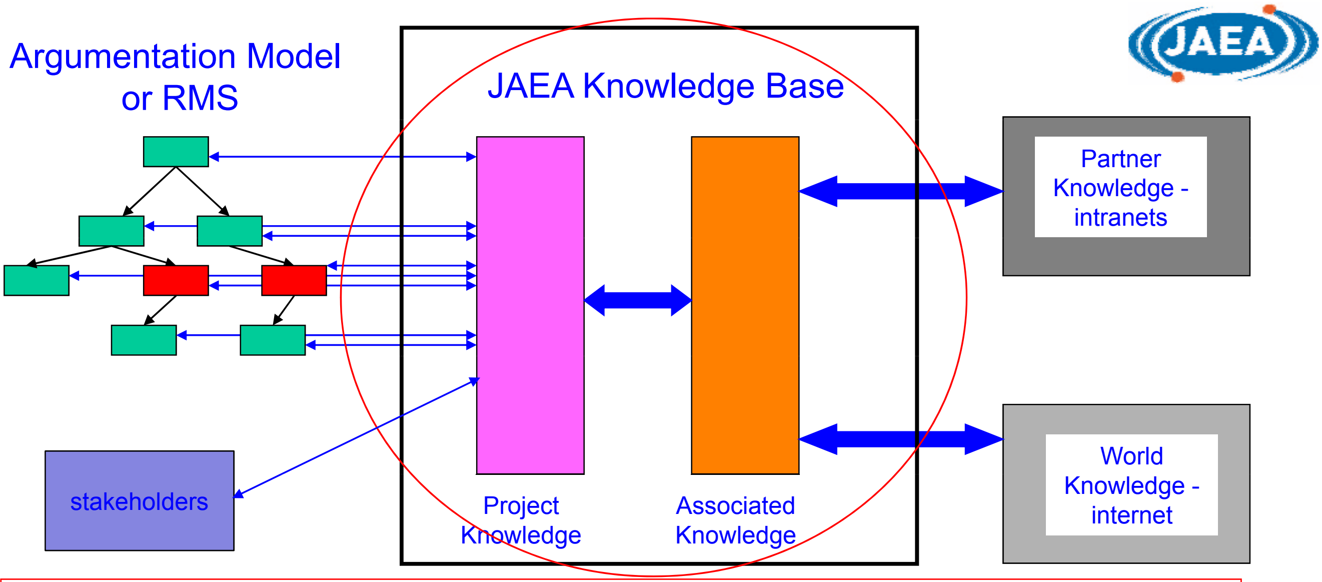

- The JAEA KB is the subset of world knowledge that contributes to development of geological disposal projects in Japan. Because of the wide definition of the "safety case", most of this can be structured by associated argumentation models or requirements management systems (RMS): however, closer to implementation a wider Strategic Environmental Assessment (SEA) may be considered (http//www.jaea.go.jp/04/tisou/kms/pdf/sc_ws_02.pdf)

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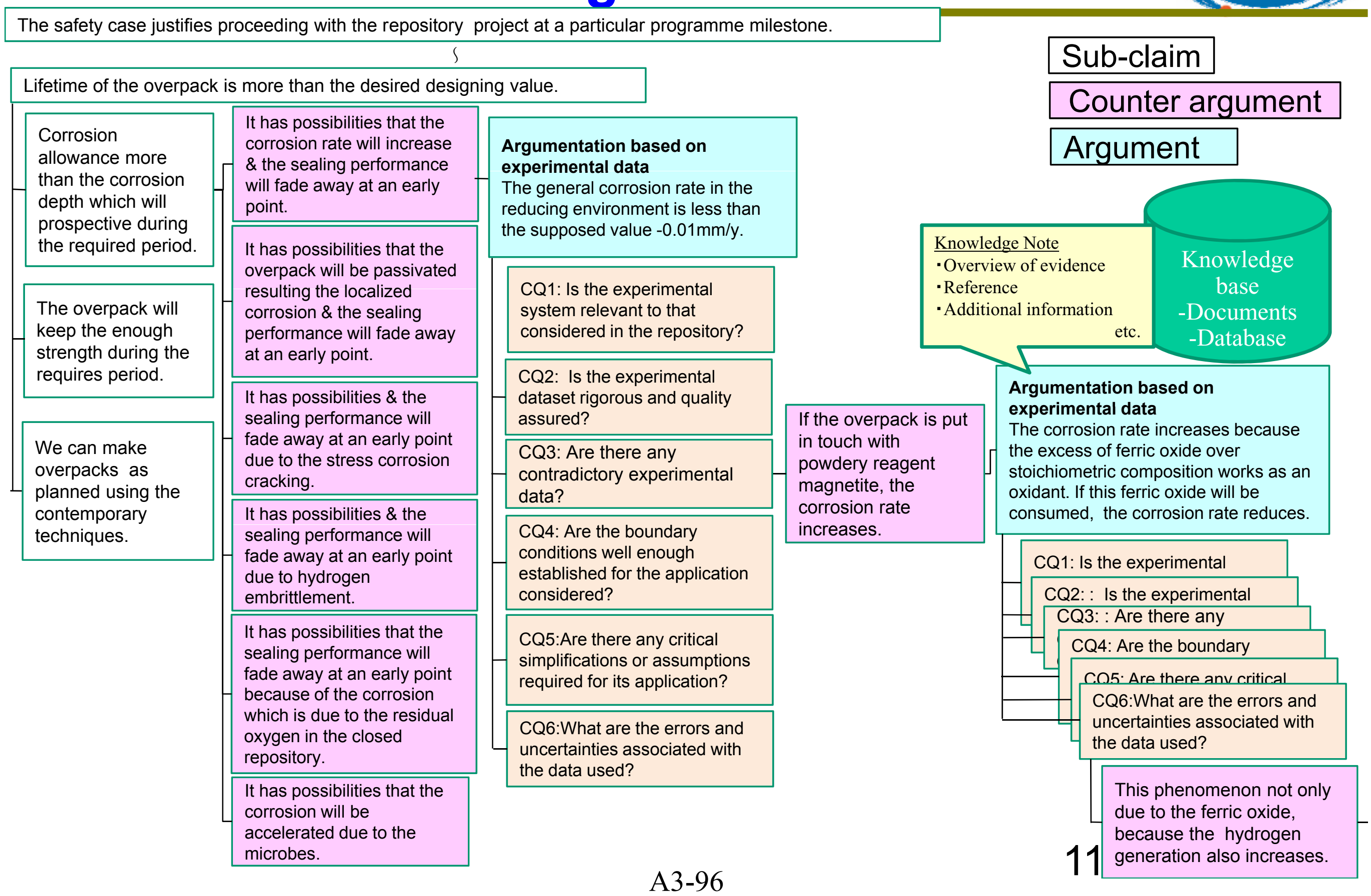
Illustration of argumentation model



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KMS Components

- The Knowledge Base (KB) is a highly dynamic entity which is intended to be a fundamental resource for implementers, regulators and other stakeholders

- The KM toolkit provides access to the KB and allows it to be
  - extended - by adding input from relevant sources
  - modified - integration & synthesis
  - reviewed - autonomous or focused QA
  - utilised - by all interested parties

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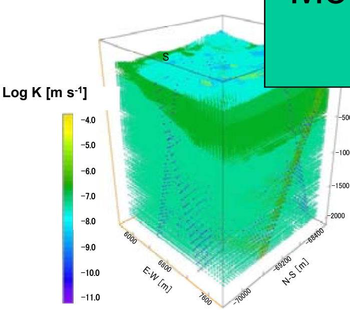
Content of a radioactive waste KB

Processed data

Synthesis reports

Model output

Expert teams



3D hydrogeological model showing distribution of hydraulic conductivity

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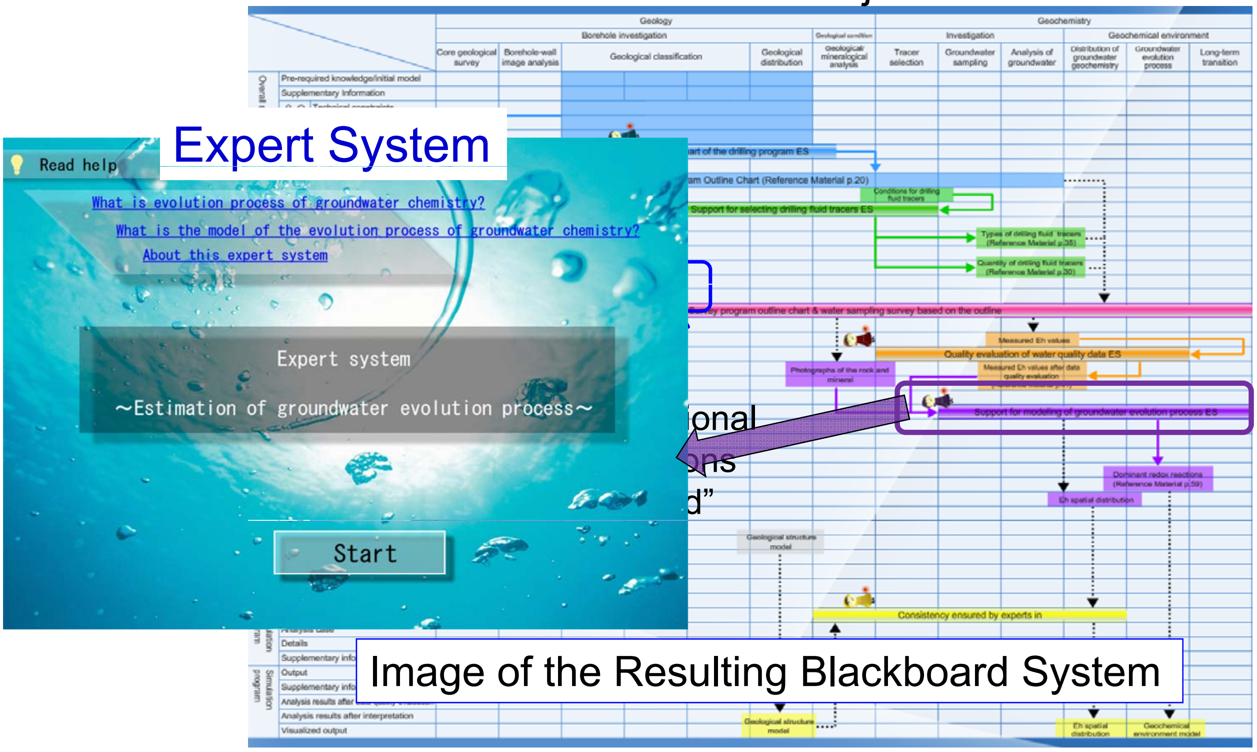
Managing tacit knowledge – Expert System

Information objects



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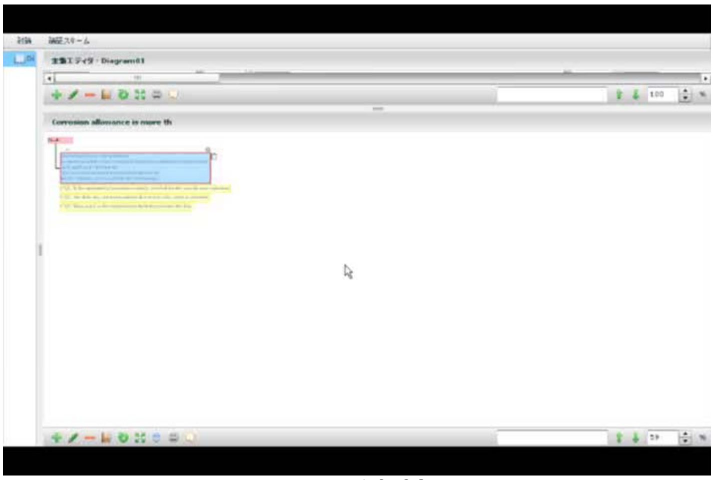
KB structuring

- Unlike traditional approaches, the database has no inherent structure: application-specific structures are imposed on the database - e.g. using hyperlinks to argumentation models
- Using expandable argumentation models and hyperlinks to full documents (focused on relevant sections), models, databases, videos, animations, etc., a comprehensive KB is generated, which can then be frozen at project milestones



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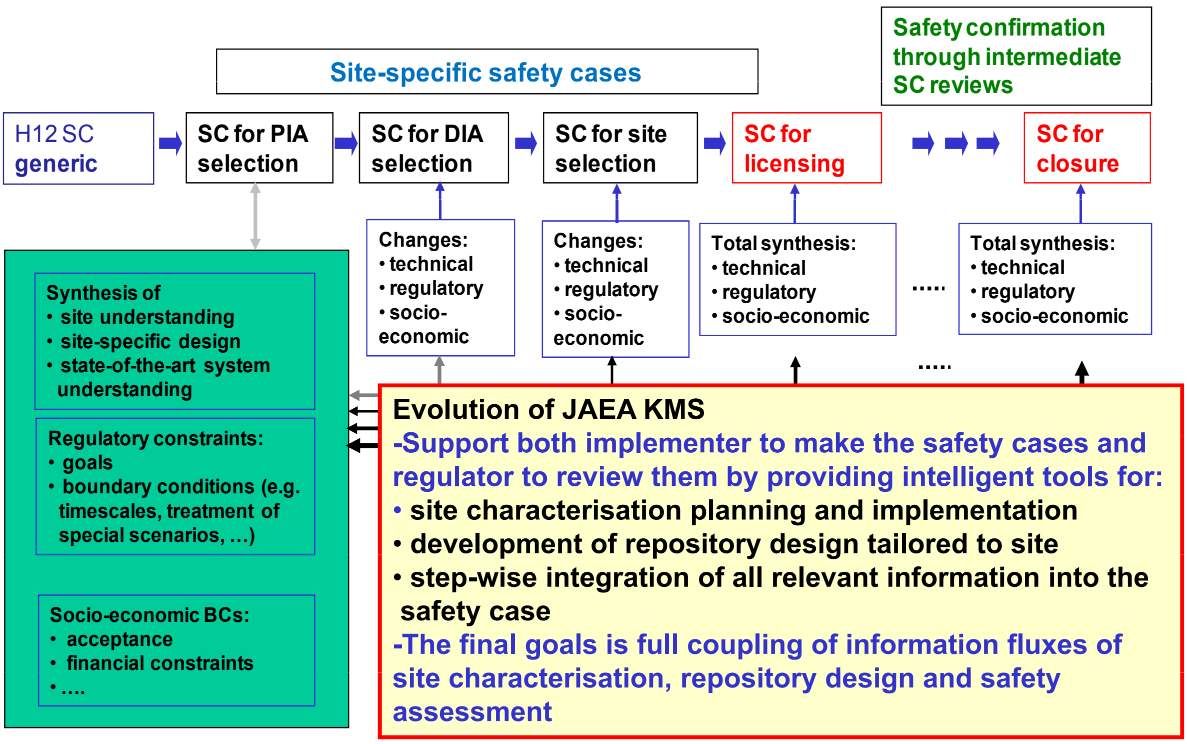
Main applications

- Focus on major areas where large flows of information must be integrated in a structured manner to provide support to the developing safety case for deep geological disposal
  - Safety case development & review
  - Site characterisation & geosynthesis
  - Repository design & PA

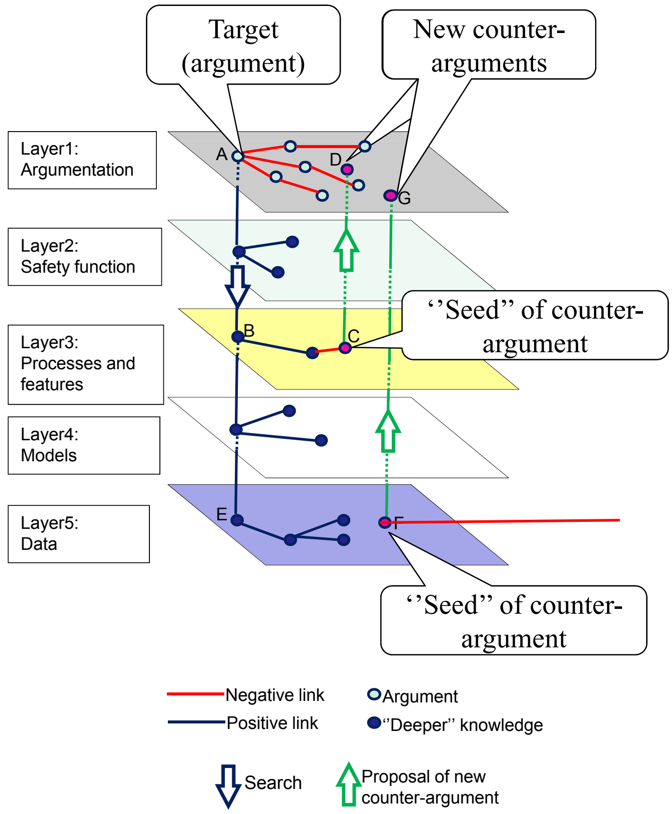
  ...although there is clearly significant overlap between these areas

Expected evolution of the KMS toolkit



Change management

- The KB continually expands and new knowledge may contribute (positively or negatively) to specific applications
- Important feature of NUMO's RMS, which is now under development (e.g. NUMO-TR-07-02)
- Might be implemented via the "alerting (notification)" function of a smart search engine



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Implementing QA – JAEA QA Workshop

Basic procedures, priorities and review work have to be carried out by expert teams - initial workshop record available at http://www.jaea.go.jp/04/tisou/kms/pdf/qa_ws_19_2.pdf

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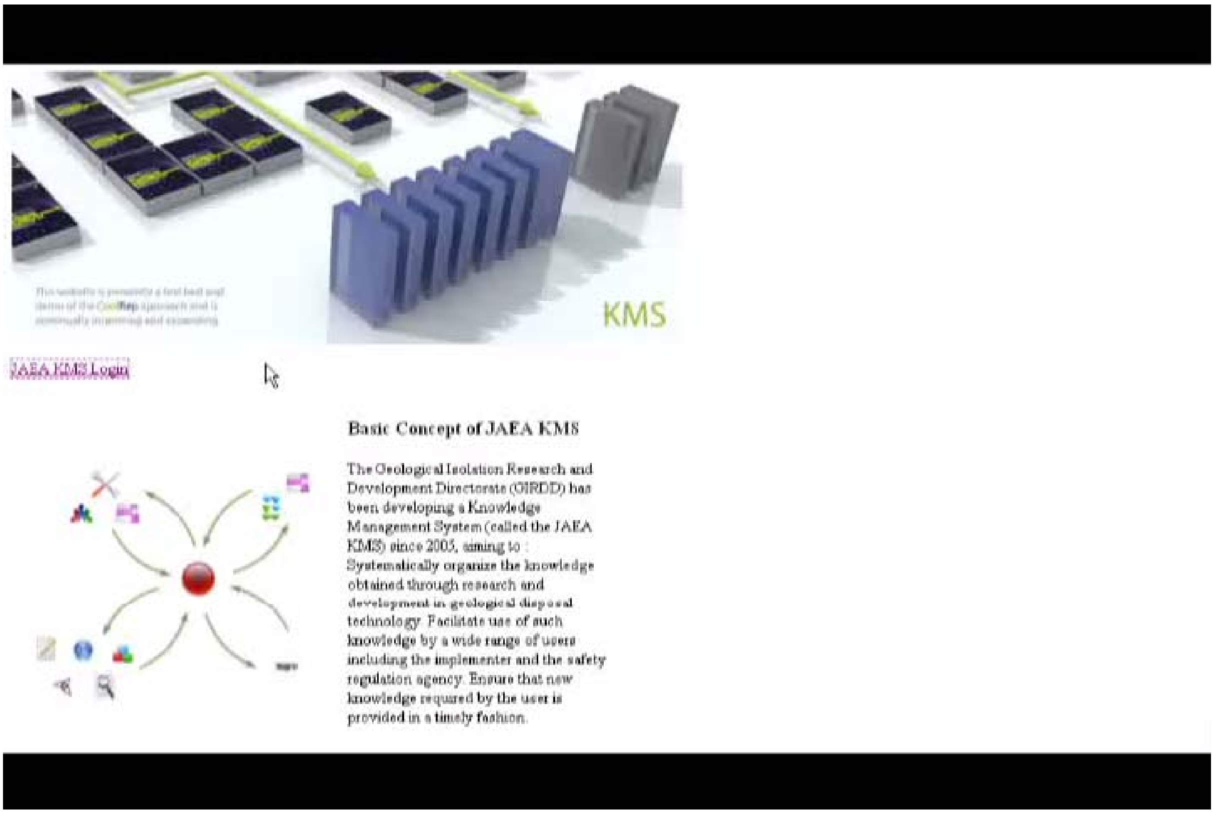
Accessing the KB

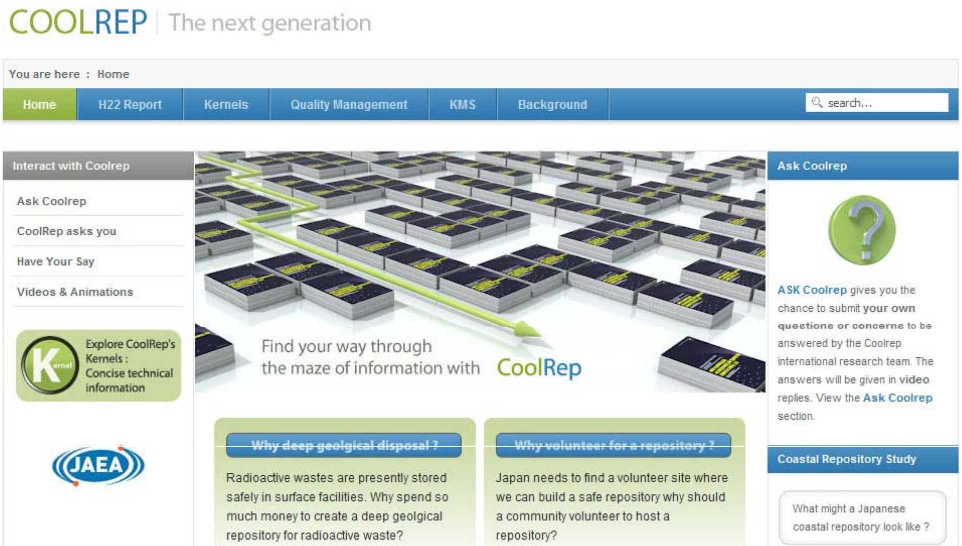
- Access via:
  - CoolRep / H22 report
  - Argumentation models
  - Smart search engine (planned development)
    - integrates focused electronic search with functionality such as:
      – automated translation
      – automated summarisation / quality checks
    - initial attempt to develop system from scratch failed
      – better approach seems to be tailoring existing specialist search engines (e.g. FAST ESP, Autonomy IDOL)
      – features include: connectivity, data cleansing & linguistic analysis, federated search, entity extraction, faceted search, contextual search, relevance & ranking, scalability, security and alerting
      – “alerting” - autonomous identification of new material on a topic - could be the basis for a change management function

KMS user interface



CoolRep

• CoolRep developed as the interface to H22 – also providing easy access to all supporting documentation.
• CoolRep specifically designed to communicate with a wide range of stakeholders…



Conclusions and future perspectives

- Significant progress has been made in establishing the KB to support the H22 project and the tools that provide access to it
- A number of different approaches have been examined but, to date, those based on argumentation models appear most generally useful
- Effort is focused on establishing as much automatic functionality as possible, but it is accepted that practical application requires a hybrid approach - facilitating the work of project teams is the main goal
- Some major challenges have not yet been addressed
  - KB freezing, archiving and security
  - Smart search engine development
  - Development of interface with knowledge producers

Session 3

Session 3: RMS in other industries – What can we learn? (Chair: S. Vomvoris)

Application of RMS for the management of major projects; examples from the Aerospace industry (H. O'Grady)

Experiences of Requirements Management in the Aerospace Industry

Henry O'Grady
Parsons Brinckerhoff Ltd

Tokyo, Jan 2010

Scope of this presentation

- Experiences of Requirements Management outside the Nuclear industry
- Not intended to be original: you may already have solved most of the issues
- My own experiences
  - presented in a way which I hope is relevant to NUMO's mission and current activities
- Mainly on aerospace / defence experience
  - where RM is well accepted and usually mandated

Contents

- My background
- Examples of Requirements Management application
- Requirements Management as a process within the larger project
- Generic stages or the implementation of a Requirements Management System
  - with some points and lessons from each

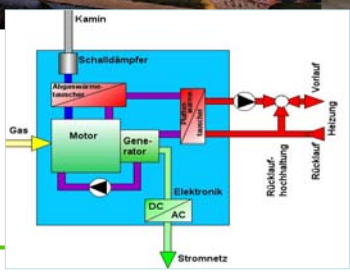
My background

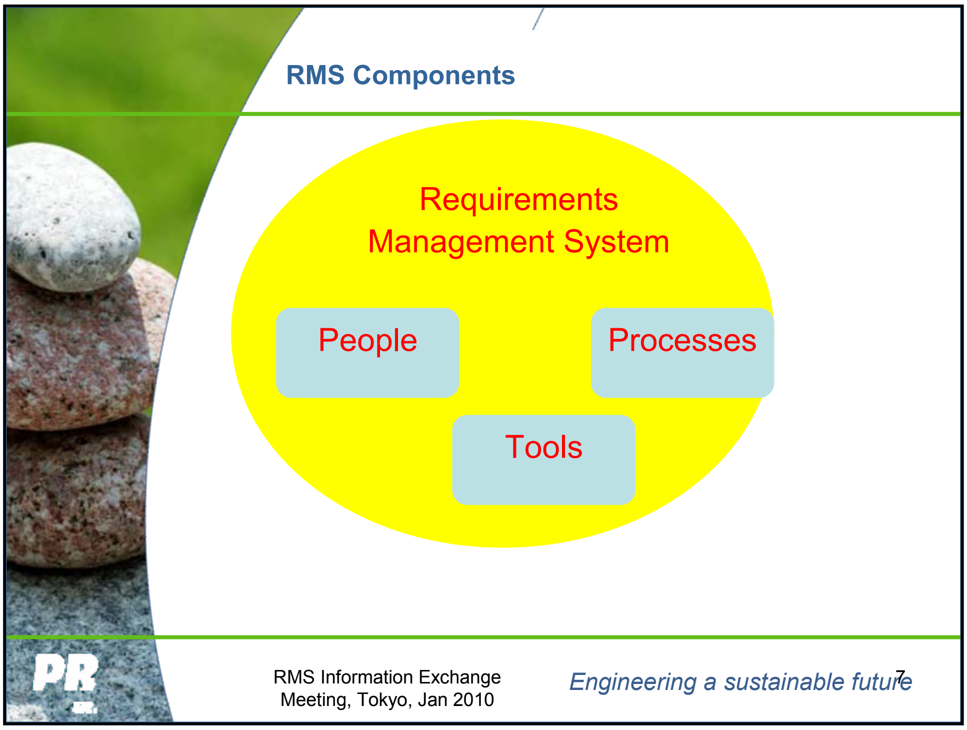
- Mainly Aerospace / Defence
- Explosives engineering
- Engineering consultancy
- High energy-rate simulation software
- Avionics systems
- Weapon systems
- Project management
- Process definition, including Requirements Management Systems

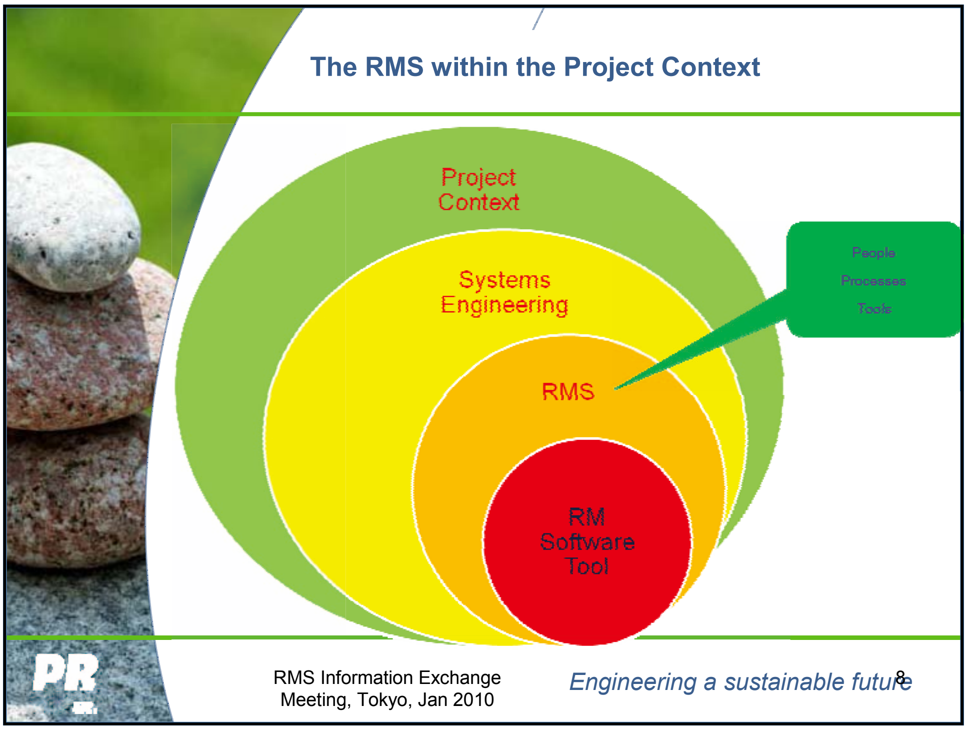
Requirements Management Applications

Note: this is a schematic diagramme of a “Generic” aircraft and fittings

Requirements Management Applications: London Olympics – Combined Cooling Heat and Power




RMS Components
Requirements Management System
People
Processes
Tools
RMS Information Exchange Meeting, Tokyo, Jan 2010
Engineering a sustainable future
7


The RMS within the Project Context
Project Context
Systems Engineering
RMS
RM Software Tool
People
Processes
Tools
RMS Information Exchange Meeting, Tokyo, Jan 2010
Engineering a sustainable future
8

Generic Stages of an RMS

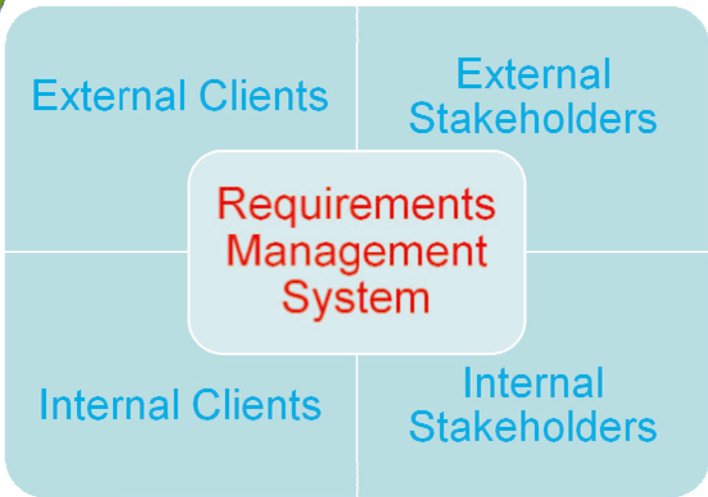
- Client relationship
- Justification / Business Case / Funding
- Process definition
  - Software specification
- Procurement / Staffing / Organisational Structure
- Roll-out
  - Pilot project
  - Proving the benefits
  - Process improvement
- Full implementation
- Demonstration of added value
- Continuous improvement
- Closure

Client relationship

- RM is well-established in some industries, not recognised in others
- Client may have own RMS
- Client may have own project Lifecycle and Milestones
- RMS may be excellent selling point in its own right

- Define the “clients” in detail
  - Who, exactly, in the Client organisation ?
  - Client Project Manager ?
  - Client’s Client ?

Clients & Stakeholders



Justification / Business Case / Funding

- Run RM implementation as a project, with milestones
- Include budgeting and cost control
- Define staff requirements: who, how many
- Define benefits, and who for
  - Absolutely key to getting support
  - Define the RMS deliverables eg single set of requirements to contract against
- Find senior level "champion"
- Formally identify Stakeholders
  - Who are they: organisation, peoples' names
  - What do they want
  - What "language" do they speak (ie commercial, project, engineering, IT, etc)

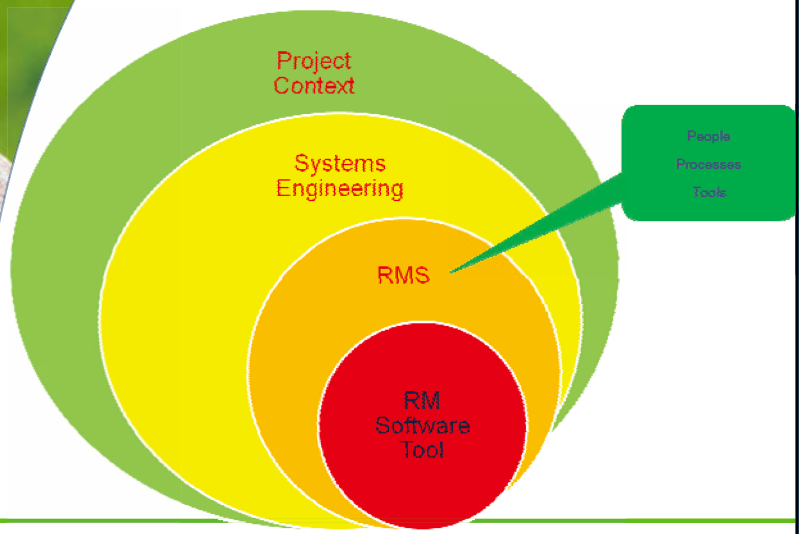
Funding

- Funding may be in tranches, conditional on demonstration of benefits
- This is very beneficial
  - Keeps RM as high profile
  - Provides delivery of RMS in stages
  - Ensures active reporting to senior management
  - Ensures RM is part of the project
  - Focusses the RM delivery team on proving the benefits
  - If these can't be done, then good to know early !

Process definition

- RMS should be defined just as any other engineering process
- RMS should include appropriate use of Systems Engineering methods
- Key features:
  - Ease of use
  - Minimal additional staff / resources
  - Full integration into project process (after pilot has proven itself)
  - Defined Inputs and Outputs
  - Provable benefits
- Integration with project / engineering milestones

The RMS within the Project Context



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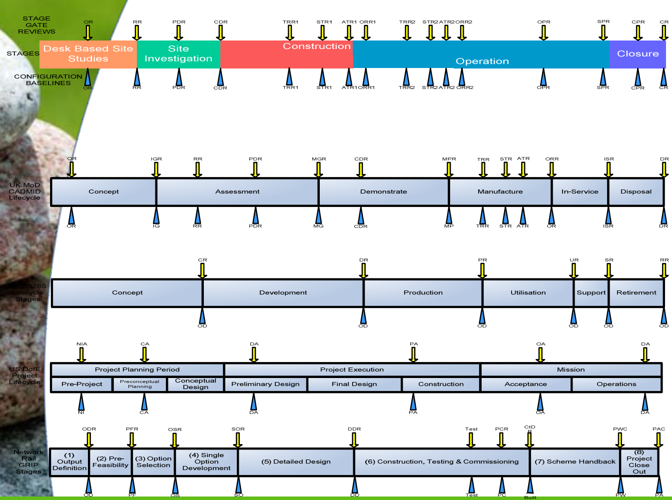
Generic Systems Engineering / Project Lifecycles



KEY:
OR – Optioneering Review
RR – Requirements Review
PDR – Preliminary Design Review
CDR – Critical Design Review
TRR – Test Readiness Review [1]
STR – System Test Review[1]
ISR – Installed System Review[1]
ATR – Acceptance Test Review[1]
ORR – Operational Readiness Review[1]
OPR – Operational Performance Review
SPR – System Performance Review
CPR – Closure Performance Review
CR – Closure Review

NOTES:
1 – These reviews are split into two parts to reflect the ongoing Construction Stage of additional ILW/LLW vaults and HLW/SF during the Operational Stage.

KEY to CADMID:
OR – Options Review
IGR – initial Gate Review
RR – Requirements Review
PDR – Preliminary Design Review
MGR – Main Gate Review
CDR – Critical Design Review
MPR – Main Procurement Review
TRR – Test Readiness Review
STR – System Test Review
ATR – Acceptance Test Review
ORR – Operational Readiness Review
ISR – In-Service Review
DR – Disposal Review

KEY to 15288:
CR – Concept Stage Review
DR – Development Stage Review
PR – Production Stage Review
UR – Utilisation Stage Review
SR – Support Stage Review
RR – Retirement Stage Review

KEY to US Department of Energy:
NIA – New Initiative Approval Review
CA – Concept Approval Review
DA – Development Approval Review
PA – Production Approval Review
OA – Operational Approval Review
DA – Deactivation Approval Review

KEY to GRIP:
ODR – Output Definition Review
PFR – Pre-Feasibility Review
OSR – Option Selection Review
SDR – Single Option Developement Review
DDR – Detailed Design Review
Test – Installed Test Review
PCR – Practical Completion Review
CtDR – Conformance to Design Review
PWC – Practical Works Acceptance Review
PAC – Project Acceptance Review

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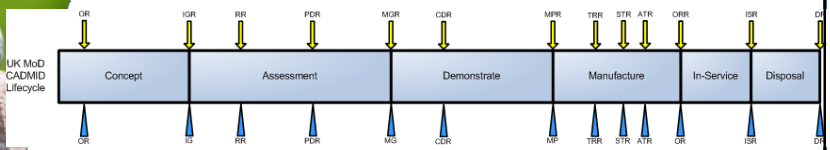
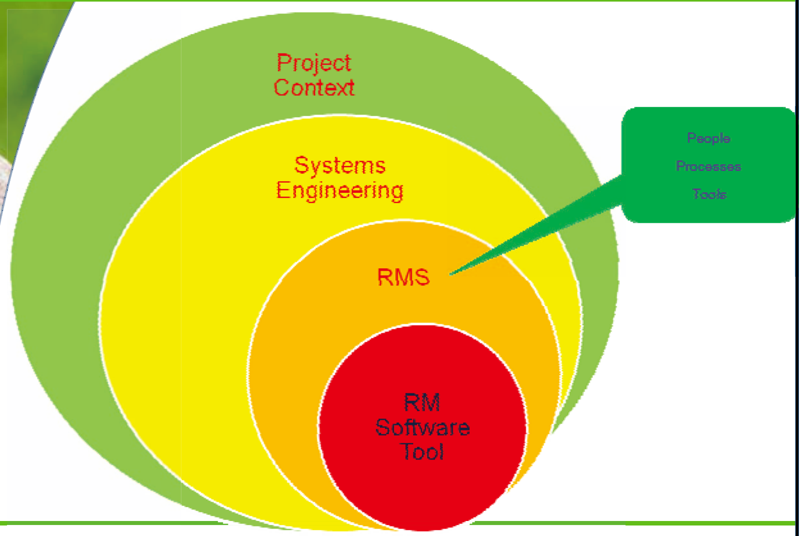
Typical Engineering Lifecycle



- CADMID Lifecycle
- Used by UK MoD
- Technical / engineering reviews
- Stage Gates / "GO – NO GO" Milestones

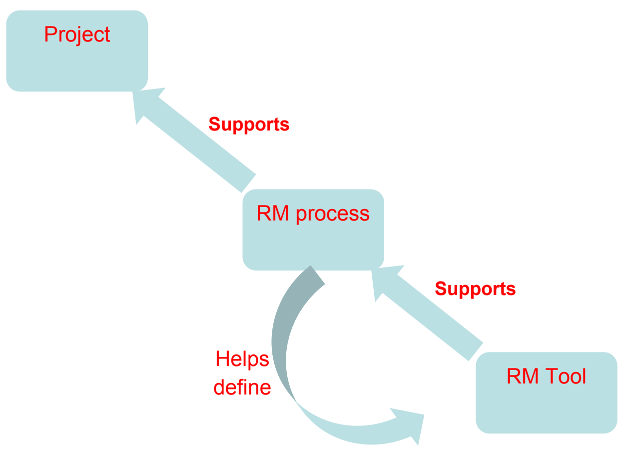
The RMS within the Project Context



Systems Engineering applied to the software tool

- The need for any software tools should arise from the definition of the desired process
  – Then can specify the software tool
  – Again, can use the full suite of RM methods to specify and procure / develop the software tool

- Essential to apply the same approach to the systems engineering of the RM process and software that will be applied to the overall product
  – Good test of the Systems Engineering process
  – Identifies areas of the SE process that don't add value
  – SE team is seen to be "walking the talk"



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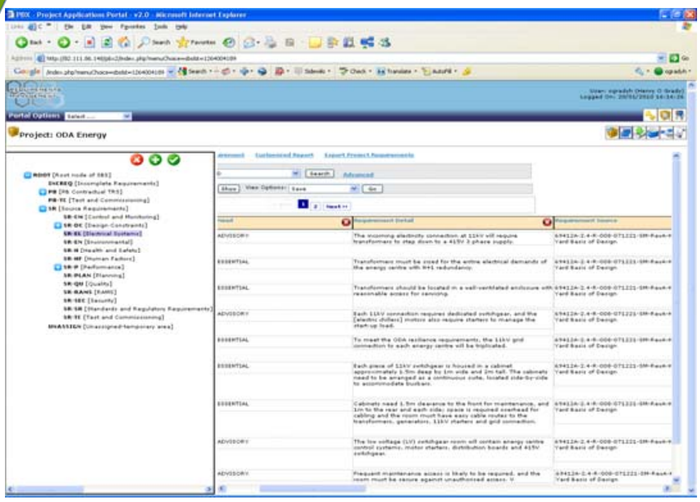
Development of PBRMS Software Tool



Procurement / Staffing / Organisational Structure

- Need some specialist staff, and good project management
  - “Project management” skills versus “data entry and data maintenance”
  - “do-it” types vs “plan it” types
- Careful definition of the roles of other functions
  - IT
  - Projects
  - Commercial
  - Configuration management
  - Engineering
  - Project management
- Role of Chief Systems Engineer

Procurement / Staffing / Organisational Structure (2)

- Training and familiarisation are key
  - For management as well as engineering staff
- And possibly the External Client & Regulators

- Organisation of the RM function should map onto the External Client organisation
  - Foster External Client liaison at low levels of the organisation

Cooling the Tube

Roll-out

- Pilot projects
  - will provide early and low-cost identification of areas for improvement
  - will provide early demonstration of benefits
  - and confirmation that the business case objectives are met
  - and that objectives can be proven to have been met
- Pilot can be focussed on
  - a specific part of the organisation
  - a sub-set of the requirements

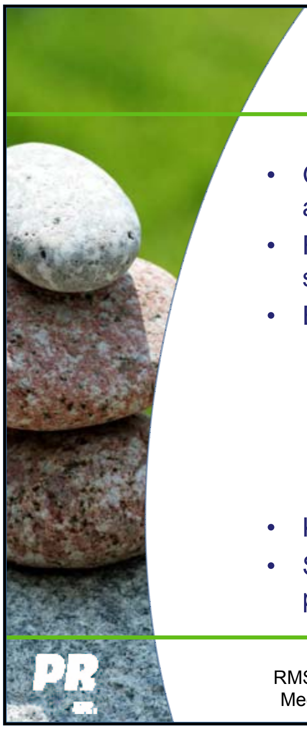
Full Implementation

- Approach must be flexible
  - Staff may change
  - Stakeholders and regulators don't behave ideally
  - Funding will change
  - Organisation will change
- At this stage the RM team must be fully part of the project team
- The Requirements Management System and the RM software must be the primary systems/tools used
  - For example. must not let people keep using WORD or Excel and only use the RMS as an archive

RM Process: Continuous Improvement

- Regular formal process reviews
- Monitor good practice across industry and in other industry sectors
- Issues or suggestions log, with single owner responsible for RMS process improvement
- Need formal process for CI

- Capability Maturity Models
  - The RMS can be formally audited against CMM Levels 1 to 5
  - Provides a basis for target-driven improvement
  - In the longer term, important to integrate the different CMMs across various disciplines



RM Software Tool Improvement

- Good communication between software developers and the RM team
- RM team should know something of the difficulties of software development, and vice versa
- Emphasis on
  - data entry,
  - data update
  - configuration management
  - reporting for Project Managers

- Keep issues log
- Schedule formal software updates, addressing priorities

Closure

- Stop using RM software, re-deploy staff
- Archive of data and change histories
- Knowledge management principles apply
  - Data must be available over lifetime of the project and beyond
- Data migration to future software tools will be necessary in the longer term
- Data formats will become obsolete
- Decisions on paper / low-tech data formats
- Do a formal Lessons Learned and transmit the lessons

Trade-offs – Optimised for Specific Project

- Terminology – local versus global
- Electronic data storage versus paper
- RM software tool versus MS WORD
- How far down the Systems Engineering hierarchy should be automated ?
- Integration with Customer and Contractor Requirements Management systems
- Technical specialists versus project managers
- Inward facing staff versus outward facing

Main Points

- RMS as a formal project
- Identify Customers and Stakeholders
- Application should be tailored to the people involved, the product, the external Client, existing internal processes
- Staged approach to implementation
- Identify benefits and then demonstrate them
- RM software tool specified around the overall RM process
- Use RM processes on the RMS itself

Annex: Generic CMM Levels

- Level 1 – Exists, undocumented
- Level 2 – Repeatable
- Level 3 – Defined and consistent
- Level 4 – Managed, uses metrics
- Level 5 – Optimized: with continuous improvement

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