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Background to the KMS and plans for H22

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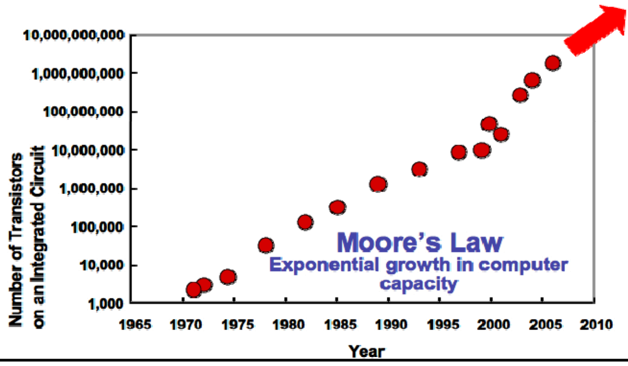
Need for knowledge management?

- **Based on the volume of information to be handled, it is no longer a question of whether advanced KMS will be introduced into radwaste management programmes or not – only whether such systems can be developed and implemented before total collapse of conventional approaches!**
- **The Japanese decision to rapidly move into advanced KM was driven by the boundary conditions of the national programme. In particular, imminent loss of many experienced staff as they retire leaves only a small window to capture tacit knowledge (common problem throughout the nuclear industry).**

Specific issues for geological disposal

- Information explosion parallels - and is driven by - exponential growth in computing power (continually exceeding expectations – **rate of growth** of information has climbed from 2002 to 2007; doubling time dropped from 3 to 1.5 years!)
- Clearly especially problematic for areas like radwaste disposal; multidisciplinary with very long implementation timescales

⇒ Breakdown of conventional approaches is evident here



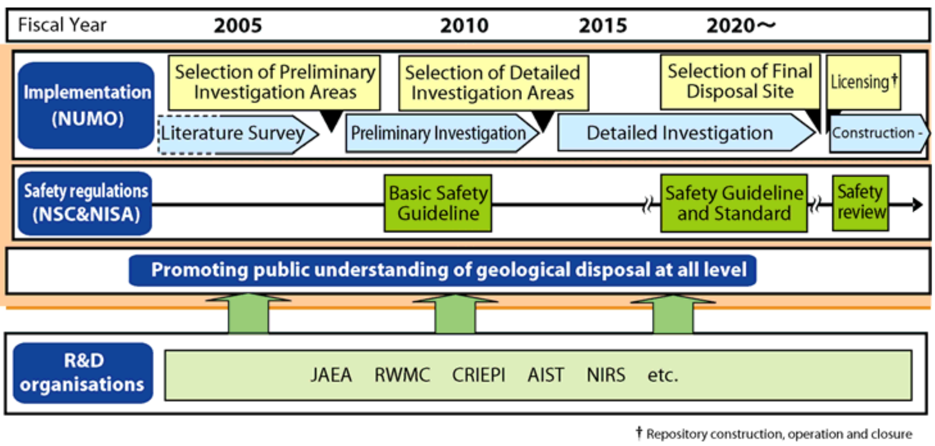
Repository:

Operation ~ 2035?
10^6 x present capacity / speed

Closure ~ 2095?
10^{14} x present capacity / speed!!!

The Japanese geological disposal programme

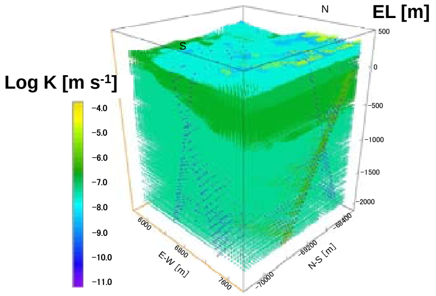
Stepwise implementation, with deadlines slipping…



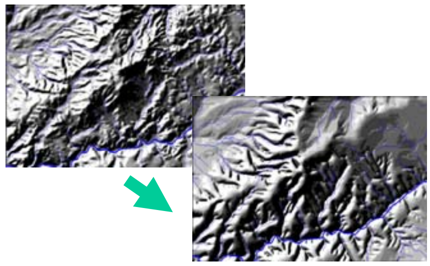
➢The Knowledge Management challenge clearly identified (JNC H17, 2005) and accepted as a key responsibility of JAEA (supporting both the implementer and regulatory groups)

Information explosion in R&D supporting geological disposal in Japan

- The size of the first integrated PA (H3) was ~ 400 pages, by the second PA (H12), 9 years later, this had expanded to ~ 2,000 pages.
- One of the greatest difficulties was integrating the huge amount of supporting information/data on geological environments, engineering and safety assessment.
- More recently, the volume of data has exploded as more synthetic modelling includes high resolution in 3D and explicit representation of evolution in time.



3D hydrogeological model showing distribution of hydraulic conductivity



An example of 3D topographical evolution predicted for Tono region

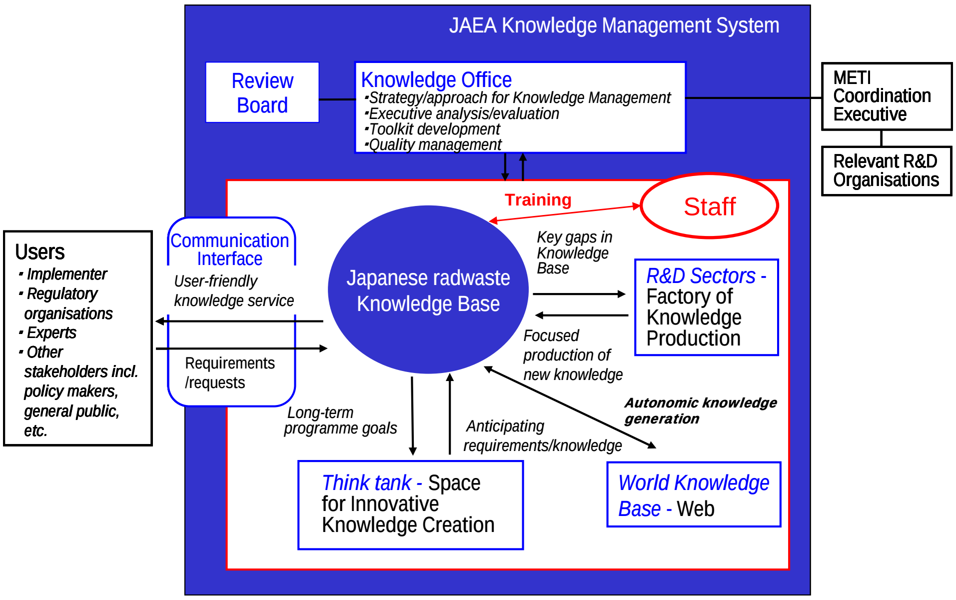
Special issues related to the Japanese programme

- Volunteering approach – uncertainties in timescales, site properties (potentially complex geology) and appropriate repository designs
- Tight schedule for early stages of site characterisation, which could run in parallel at several sites
- Considered for both HLW and “TRU” (separate facilities or co-disposal)
- Shortage of experienced staff and marked age bulge passing through all key organisations
- Commitment to openness and transparency

Fundamental concept of the JAEA KMS

- The fluxes of knowledge within a geological disposal programme are so huge that past informal approaches are clearly inadequate: formalisation of processes needs to be combined with adoption of **advanced KE technology**
- The KMS is not a passive tool to archive and disseminate information – it requires ability to autonomically synthesise and integrate material from diverse sources, identify trends and inconsistencies and give feedback to data producers.
- The KMS must allow for continuous exponential growth of the knowledge base
- Flexibility and user-friendliness is essential to encourage use by both knowledge-producers and -users.
- Emphasis is placed on advanced **electronic information management**; utilising experience in relevant areas such as **expert systems**, **artificial intelligence**, **neural networks**, **web-based agents** and **bots**, etc.

Structure and components of the KMS



Critical KMS components

- The Knowledge Base (KB) and associated archiving and maintenance tools
- Knowledge acquisition technology (for both explicit & tacit knowledge)
- Knowledge manipulation technology (for autonomic processing, quality checking, trend analysis, etc.)
- Flexible and user-friendly communication interface
- Training and transfer of tacit knowledge
- Executive coordination: including monitoring of progress and user feedback, quality management and strategy development (including initiatives to anticipate important future developments in technology or project boundary conditions)

Components of JAEA knowledge base

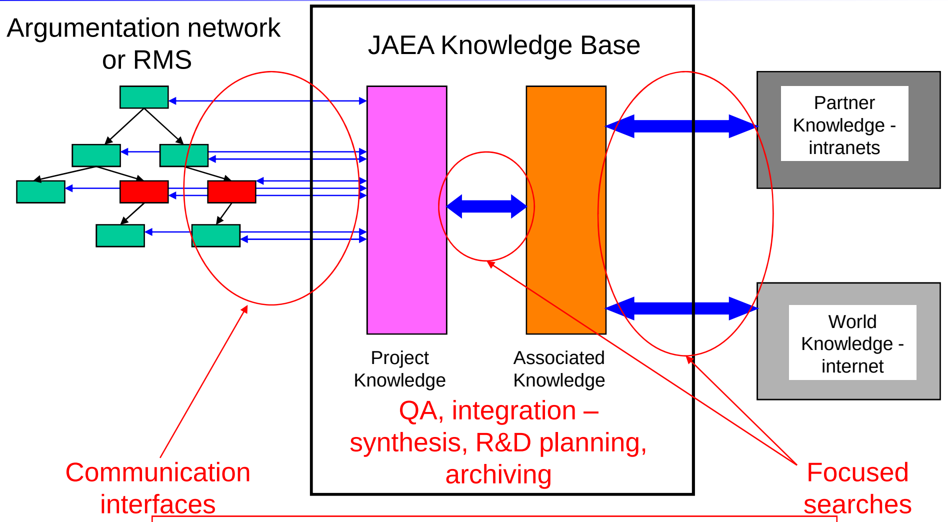
Form of knowledge	Management functions	Content	Required developments	Comments
Data	Data management	- raw data (internal) - solicited data (external) - processed data	- autonomic QA - internal & external data mining - autonomic data processing	Potential area for international collaboration
Documents	Document management	- internal documents - key external documents	- robust archive - autonomic QA / cataloguing / cross-referencing	Electronic archiving critical problem area
Software	Software management	- archive of all relevant codes / databases - archive of manuals & handbooks - archive of relevant output	- robust archive - autonomic change management - formal approaches for QA	Electronic archiving critical problem area
Experience & methodology	Resource management	- procedure manuals & guidebooks - expert systems - training materials	- use of expert systems to preserve experience - training approach for the next generation	Much of requirements could be addressed by national (regional?) training centre
Synthesis	Knowledge integration	- experienced synthesis team - expert systems	- description of key integration processes - approach to QA	Needs considerable development to automate
Guidance	Knowledge coordination	- experienced coordination team	- prediction of requirements (Think tank) - process for filling key gaps in knowledge	Very difficult to automate
Presentation	User / producer dialogue	- user friendly interfaces (interactive – allowing dialogue)	- high-end graphical methods for presenting complex information	Should be tailored to needs of different stakeholders

Roles of the intelligent assistant

Concepts

- **The Knowledge Base (KB) does not need to be rigorously structured:**
  - Standardised vocabulary (ontology) allows application of smart search engines
  - Requires rigorous file management procedures and robust security
- **The Knowledge Management System (KMS) serves to:**
  - Maintain, update and facilitate access to the KB (automated as far as possible)
  - Establish effective interfaces to Knowledge producers & users (utilising advanced communication tools)
  - Ensure development of the tacit knowledge required to perform tasks that cannot be automated (e.g. decision making)
- **KMS application is driven by the needs of users (including knowledge producers), may be formally defined:**
  - An interface to an established Requirements Management System (RMS)
  - An argumentation network flexible enough to fit the needs of all users

KMS key functions



Roles of JAEA KB:
- **secure, traceable record of all knowledge applications (database freezing)**
- **specified reference data to compare against future developments, potential triggers for change assessment**
- **identification of gaps to allow focused searches / knowledge creation**

The "intelligent assistant"

- Integrates information technology support
- Helps establish ontology
- Incorporates a toolkit for
  - Compiling explicit knowledge - **knowledge mining tool**
  - Compiling tacit knowledge - **expert system tool**
  - Autonomic knowledge manipulation – **archiving, quality testing, synthesis, integration and documentation tools**
  - Knowledge presentation – **visualisation tool**

A special concern - tacit knowledge

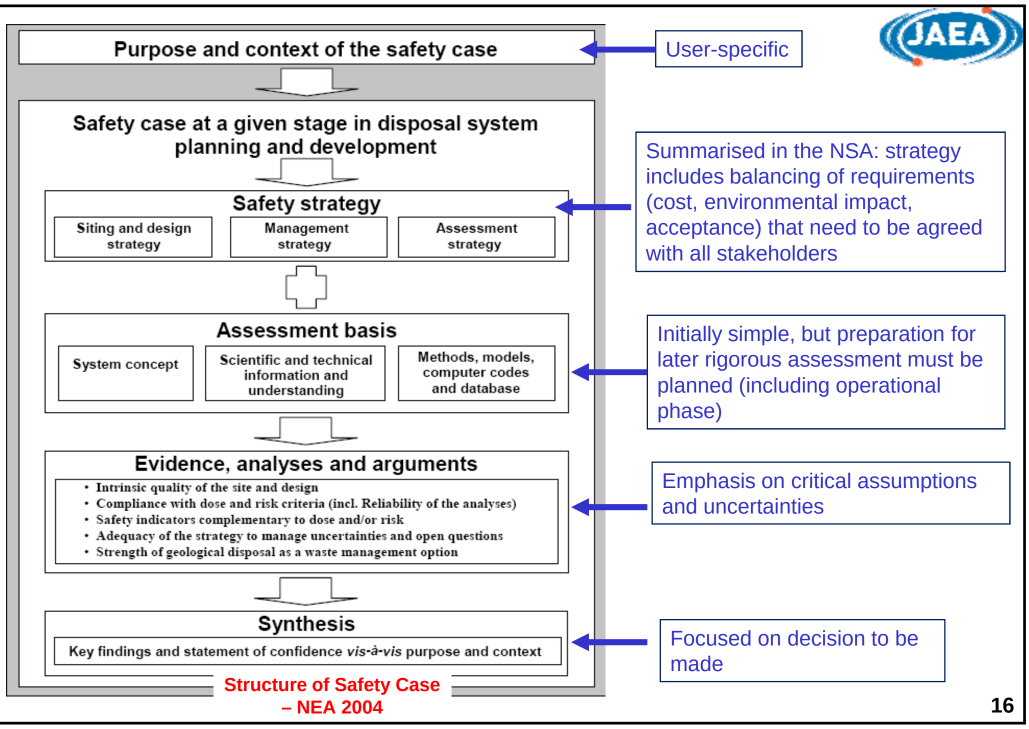
- Most KM applications noted above focus on **explicit** knowledge - that which can be readily documented
- Just as important is **tacit** knowledge - information and experience which is contained in the heads of senior staff and plays a key role in planning and decision making - particularly in pragmatic areas of multidisciplinary projects
- Tacit knowledge has tended to be managed in the past via training / apprenticeships / on-the-job experience transfer, but this is now critical in many programmes due to retirement of staff who played unique development roles
- Special training and mentoring projects may be valuable, combined with more speculative, novel approaches (e.g. based on e-learning supported by expert systems)

Coordination & leadership

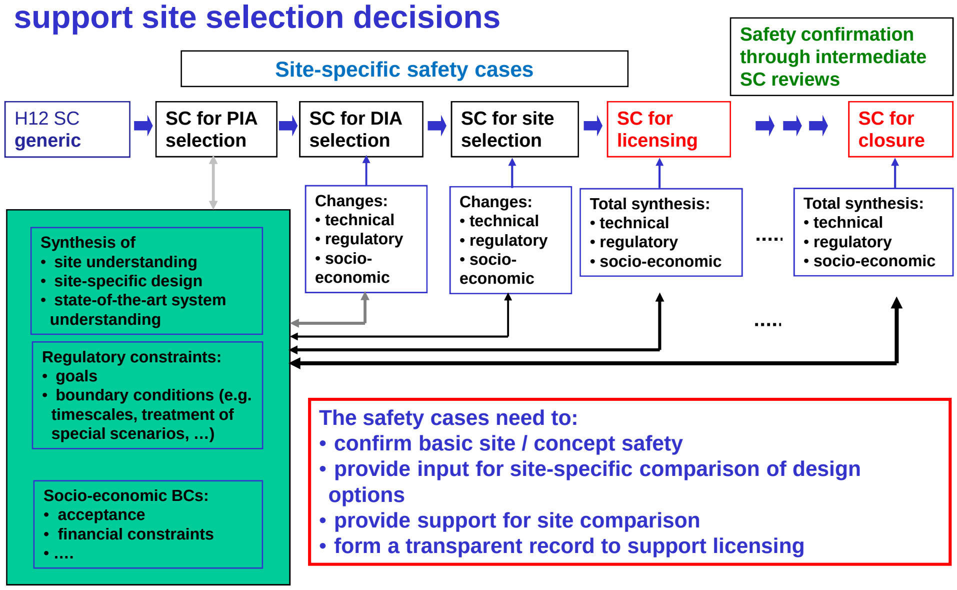
- Topics normally found in "project management" handbooks, but taboo in "hard science" projects
- Nevertheless, critical for a project that is pushing the leading edge of technology and is developed with a perspective in the order of a hundred years or so
- Executive coordination is essential to:
  - monitor progress and feedback to ensure that output is appropriate to all users (implementers and regulators, data inputers and outputers, other stakeholders)
  - assure strict quality management, as this will eventually be used to support licensing decisions for repository projects
  - strategy development (given the time frame, needs initiatives to anticipate important future developments in technology or project boundary conditions)

Ensure applicability

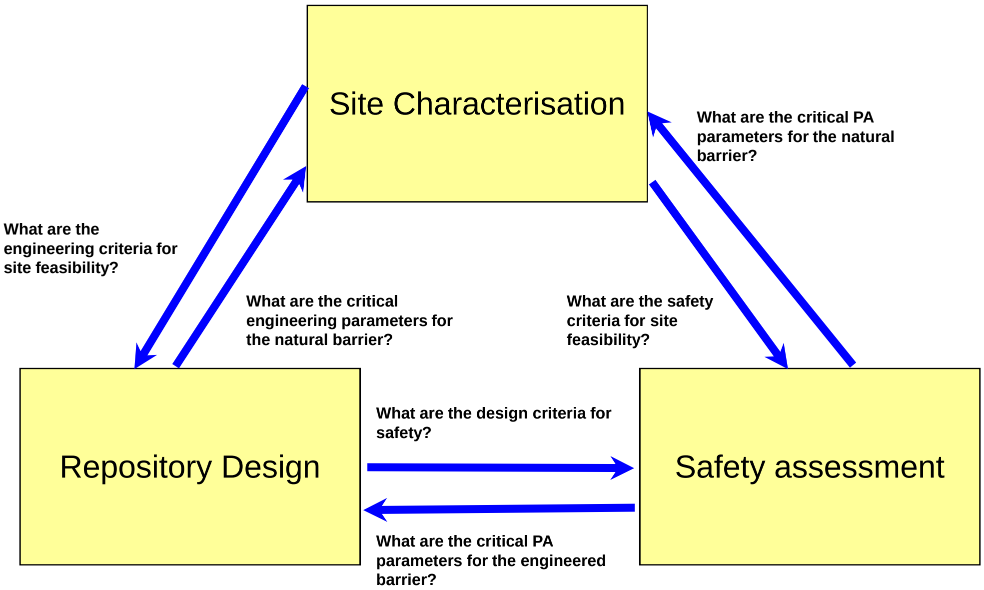
- Fundamental role for all users is related to a **safety case**:
  - Developed by NUMO, on the basis of the support provided by knowledge producers
  - Reviewed by the regulators and particular stakeholder groups, facilitated by the agreed structures and databases that the KB contains
  - The focus for discussion with other stakeholders and decision-makers, who can access supporting information in as much detail as they desire



Stepwise evolution of the Safety Case to support site selection decisions



The Goal: coupling of RC / SC/ PA



Quality management

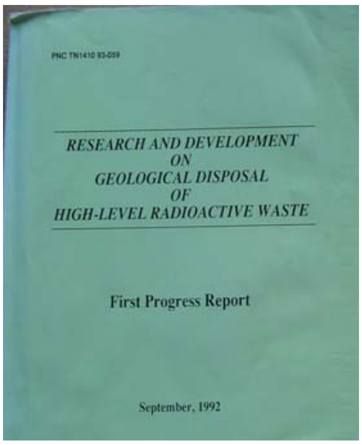
- Agreed to be essential, but has been the bane of many programmes when inappropriately applied
- Can be also be focused by the safety case – level of quality required is related to the contribution to the safety case:
  - High quality required for critical arguments (e.g. dimensions of host rock are well defined)
  - Lower levels acceptable for general supporting information (e.g. Thermal conductivity of overlying formations is characterised)
- When need for QMS can be easily explained, rigorous implementation is more likely to be accepted

Synthesis – how do we move forward?

- JAEA must provide a status report on its role to support safety case development in 2010 (H22)
- The KMS will be presented as an essential component of this support function
- Given the problems with the information explosion and our commitment to paradigm shift, we are considering a novel approach to such documentation that illustrates many of the principles previously discussed

The problems of integration & QA (1)

- In the early days, integrated PA was carried out by a small team who had an overview of all project components
- Documentation was in a single report (or a small number of slim reports), split by technical discipline – traditionally: Geology, Engineering and Safety Assessment
- QA was very informal, based on internal or limited external reviews



The problems of integration & QA (2)

- By the end of last century, extensive report series were required to document such projects
- Large reports were produced by teams with little overview of even a single discipline; large amounts of overlap and huge problems in ensuring consistency
- Formal QA introduced, but application limited due to the vast volume of material involved

The solution

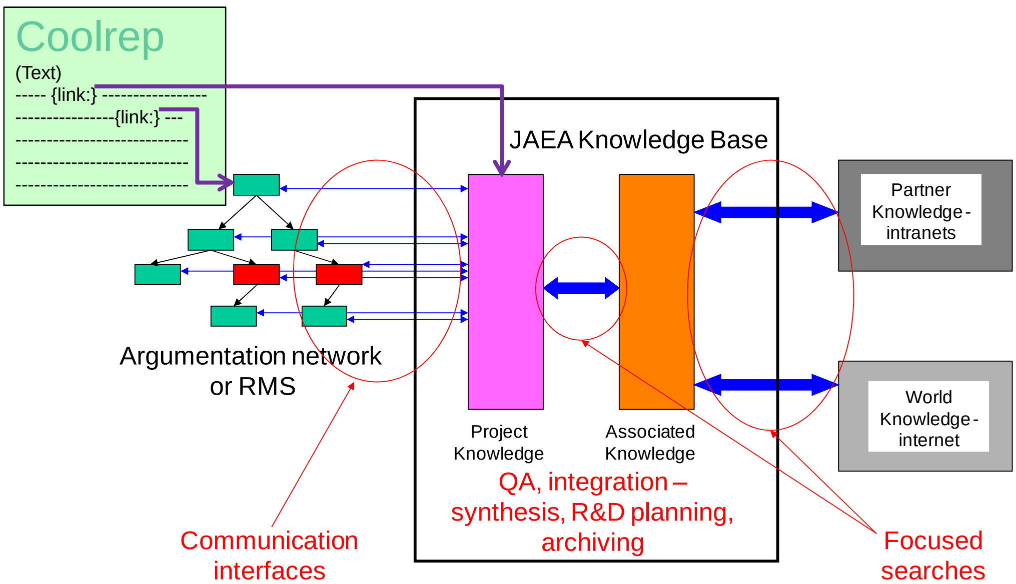
- A new approach is required, illustrating how the vast volumes of relevant information can be presented in a user-friendly manner that is accessible to a wide range of stakeholders.
- This should also make quality assurance more transparent and facilitate the complex process of identifying topics requiring future R&D and setting priorities for the use of limited resources.
- Feedback from users will, in turn, be used to improve the structuring of information and the presentation software, so that improved methodology and software tools will be available when they are needed for more critical applications – such as presenting safety cases to support site selection or final licensing of a repository.

The Coolrep idea

The report is produced entirely electronically and is provided on DVD or on the internet in the form of a short, easily readable overview (30 – 50 pages) with extensive hyperlinks to:

- Supporting text providing more detailed technical input
- Full text of key references
- Visual support material, including videos and animations
- All review and QA material
- Relevant web sites

Linkage of the Coolrep with KMS



Advantages

- The overview can focus on logical presentation of the safety case; technical support information is accessed where relevant rather than being isolated in a specialist report
- Technical depth can be increased by nested hyperlinks
- Wherever possible quality is assured by direct linking to peer reviewed text
- During production, a single read-only master exists containing the accepted updated draft; amendments of components may be produced in parallel, but contain digital signatures of the author and are added only after acceptance and digital signature of the report coordinator (assures implementation of the QM system and prevents different versions of databases being used by different groups)
- Test version is operational in a web site, allowing interactive features to be developed and demonstrated

Conclusions

- A novel challenge for KM is to provide a common scientific and technical basis for all stakeholders in the geological disposal programme.
- Development of the KMS is a challenge in itself. It seems feasible, however, using state-of-the-art IT and organisational KM tools.
- The KMS tools would free more time for – and ease the process of – top-level synthesis and decision-making, which is essential to efficient, safe, and acceptable repository projects.
- The staff implementing and regulating 21st century radwaste projects will thus have a global overview provided by advanced software, databases and interfaces.
- JAEA will “put its money where its mouth is” in the next status report (H22), which will not only describe the key KMS concepts required for next generation safety cases but also incorporate these in the document itself.
- Quality management must be implemented in a focused and effective manner that encourages all those involved to adopt a quality culture. KM tools should minimise the effort of QA while making benefits clear to users.