Knowledge Management: The Cornerstone of a 21st Century Safety Case

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Safety Case for the Deep Disposal of Radioactive Waste:
Where do We Stand?
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General context

- The safety case for a repository involves many complex, multi-disciplinary issues; these must be summarised in a comprehensive and concise manner, with links to all supporting information. The safety case is thus an edifice built on structured knowledge.
- Disposal projects are supported by, and generate themselves, huge amounts of “knowledge”. Exponential expansion of the knowledge base is rapidly exceeding what can be handled by traditional approaches.
- Thus, a project to develop novel knowledge management tools utilising advanced IT methods has been initiated.

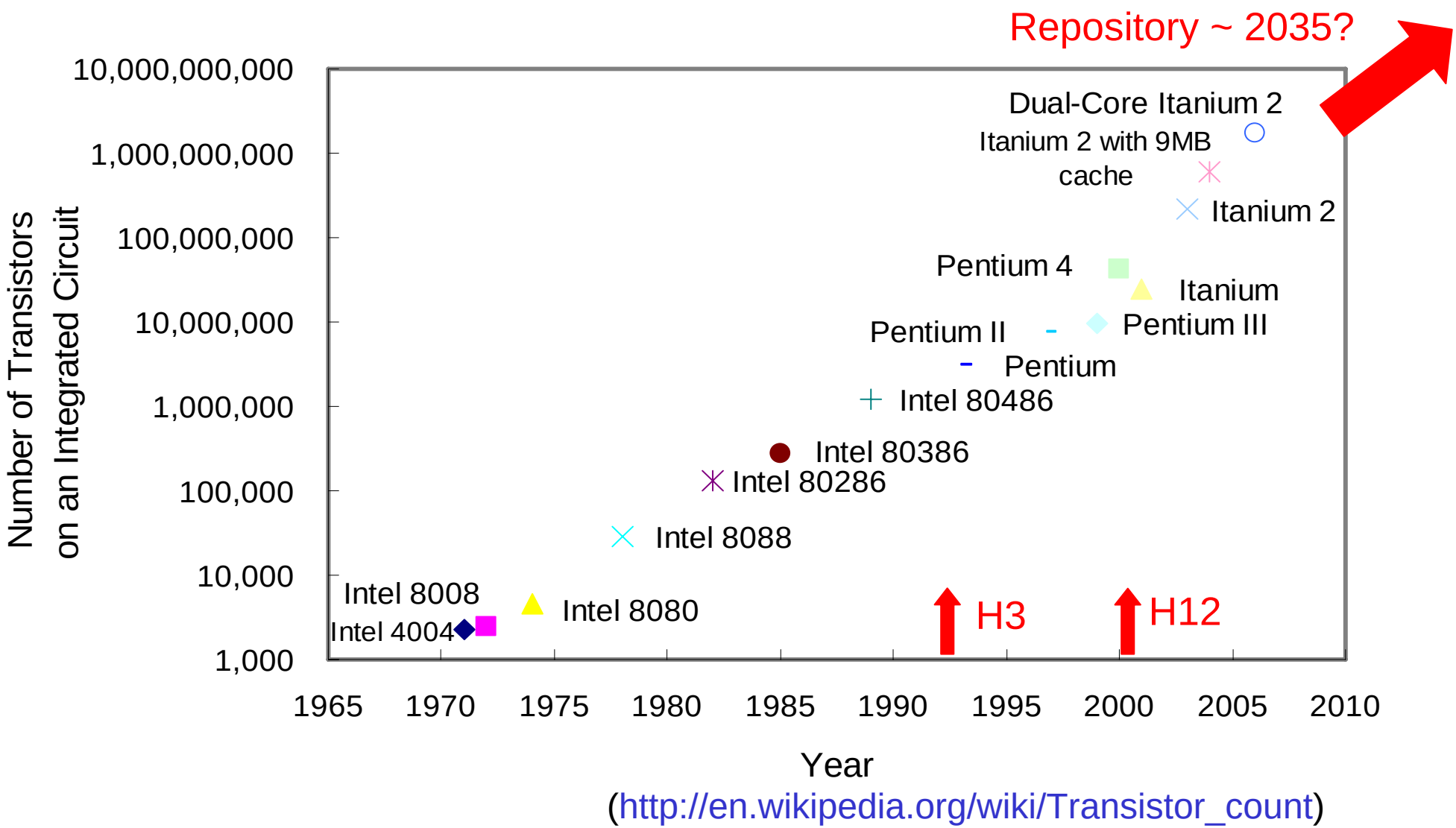
Why worry about knowledge management?

- Until the time of the Renaissance, it was possible for a genius to master all major areas of the arts and sciences (e.g. da Vinci)
- With the exponential explosion of knowledge in the 19th & 20th centuries, it becomes impossible for an individual to master all aspects of even a single scientific discipline
- By the end of the 20th century, mastering even a sub-discipline becomes extremely difficult and the integration of multi-disciplinary projects is acknowledged to be a major problem
- As exponential knowledge growth continues during the 21st century, the ability to manage information may be the most critical aspect of many projects

Knowledge in the radwaste field

- In the early days of radwaste management, individuals could have a good overview of the entire field
- By the ’80s and ’90s knowledge began to expand rapidly and few staff could overview even a single project
- At the start of the 21st century, knowledge management is recognised as a critical area – particularly due to increased requirements for openness and transparency

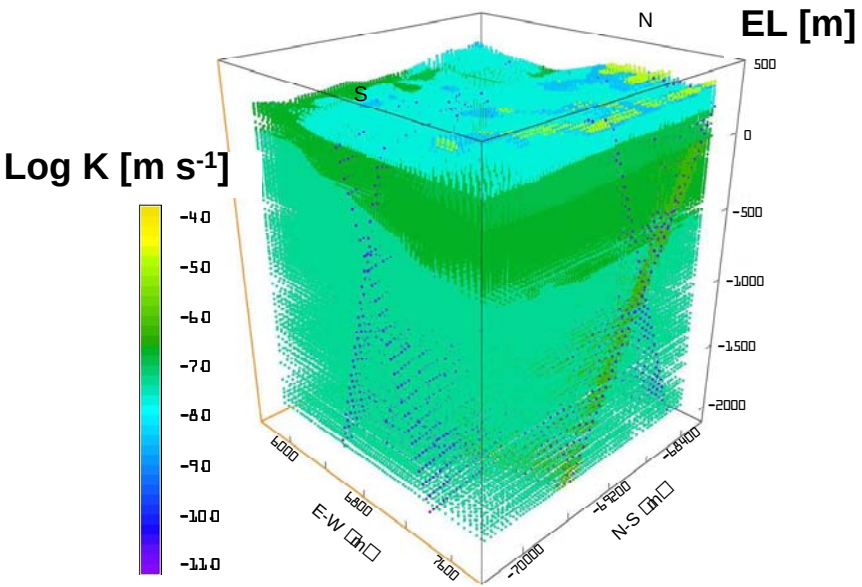
The well-known exponential growth in computer capacity illustrated by Moor's Law



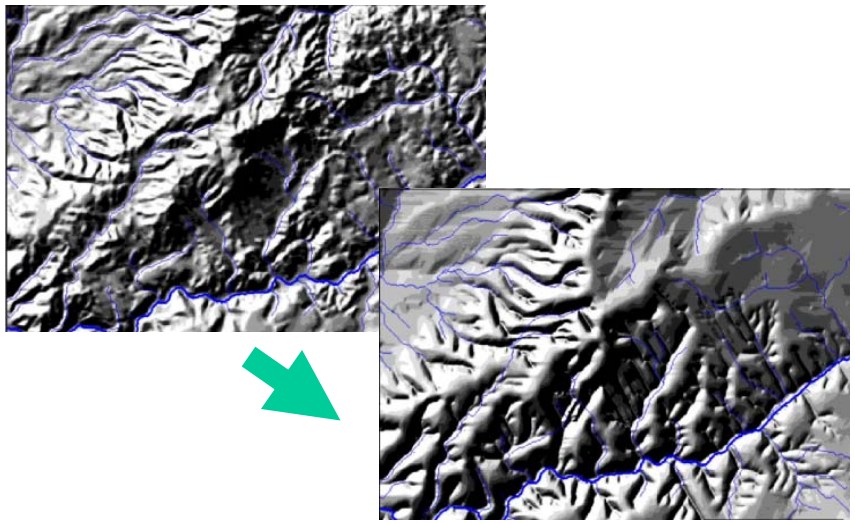
(http://en.wikipedia.org/wiki/Transistor_count)

Information explosion in R&D areas for HLW disposal programme 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 database to manage the hydrogeological model and associated hydraulic conductivity



An example of 3D topographical evolution predicted for Tono region

KM – definitions and requirements

“Knowledge”

- A global term including all science and technology underpinning a repository project – including data, understanding and experience.
- Has shown exponential growth over the last 3 decades – with no sign of tailing off.
- Existing Knowledge Management in the radwaste business is based predominantly on individual specialists complemented by staff with a global overview – OK for the 20th century but inappropriate for the 21st!

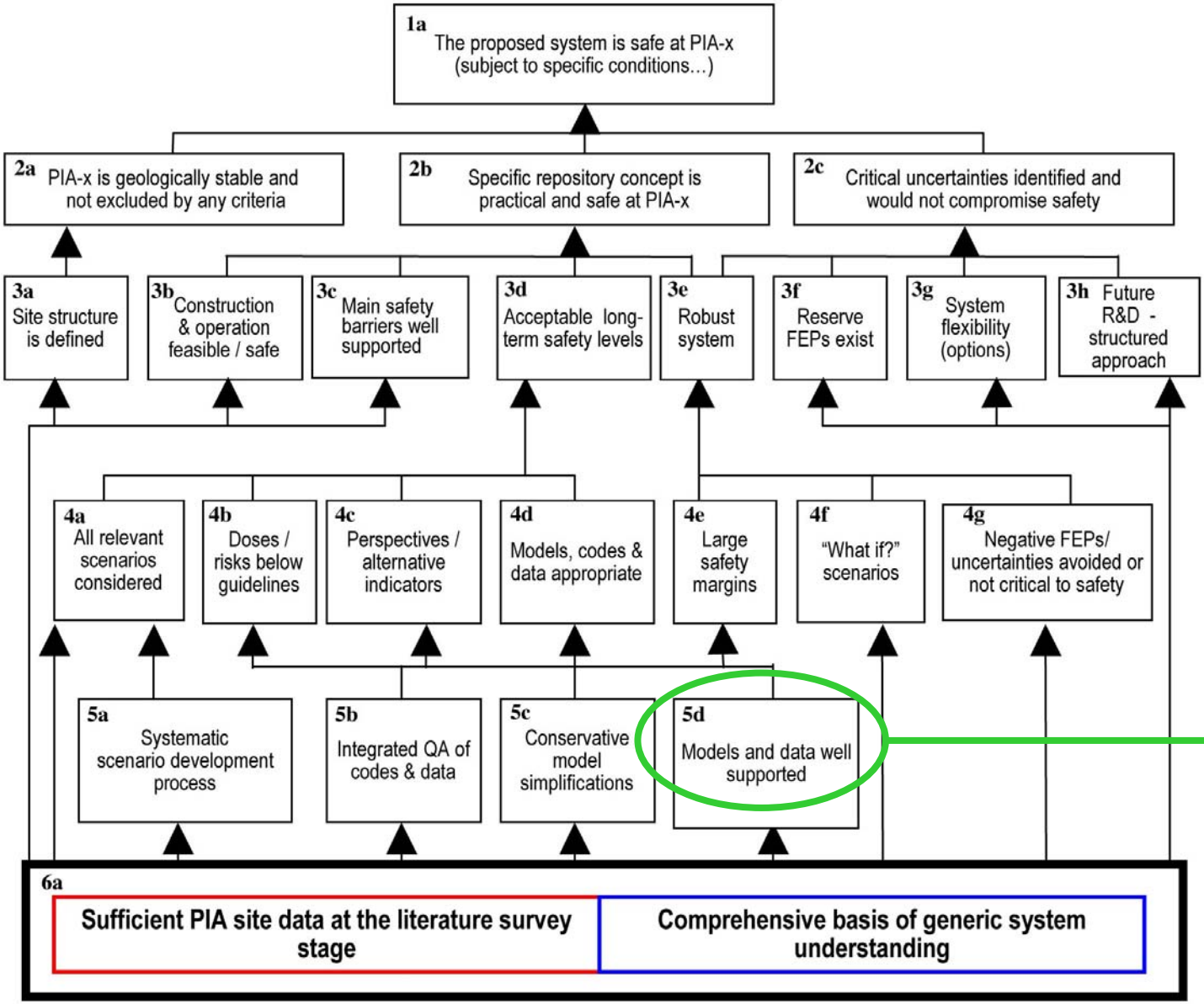
“Knowledge Management” (KM)

- Covers all aspects of the development, integration, quality assurance, communication and maintenance/archiving of knowledge.
- Knowledge evolves with time in line with progress in science and technology. In addition, experience is accumulated directly by individuals.
- Ideally, knowledge should be objective and value-free but, in practice, is conditioned by the opinions of the staff involved. KM thus includes evaluation of potential biases, in addition to more standard assessment of conceptual and data uncertainties.

Fundamental concept of the proposed KMS

- Structure existing knowledge on the basis of the requirements of end users: could interface directly to a requirements management system.
- Initially, the Safety Case can be used to structure knowledge.
- The KMS is not a passive tool to archive and disseminate information - requires ability to synthesise and integrate material from diverse sources, identify trends and inconsistencies and give feedback to data producers.
- The KMS must allow for the rapidly growing knowledge base, with flexibility and user-friendliness 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.

Safety Case – knowledge flows

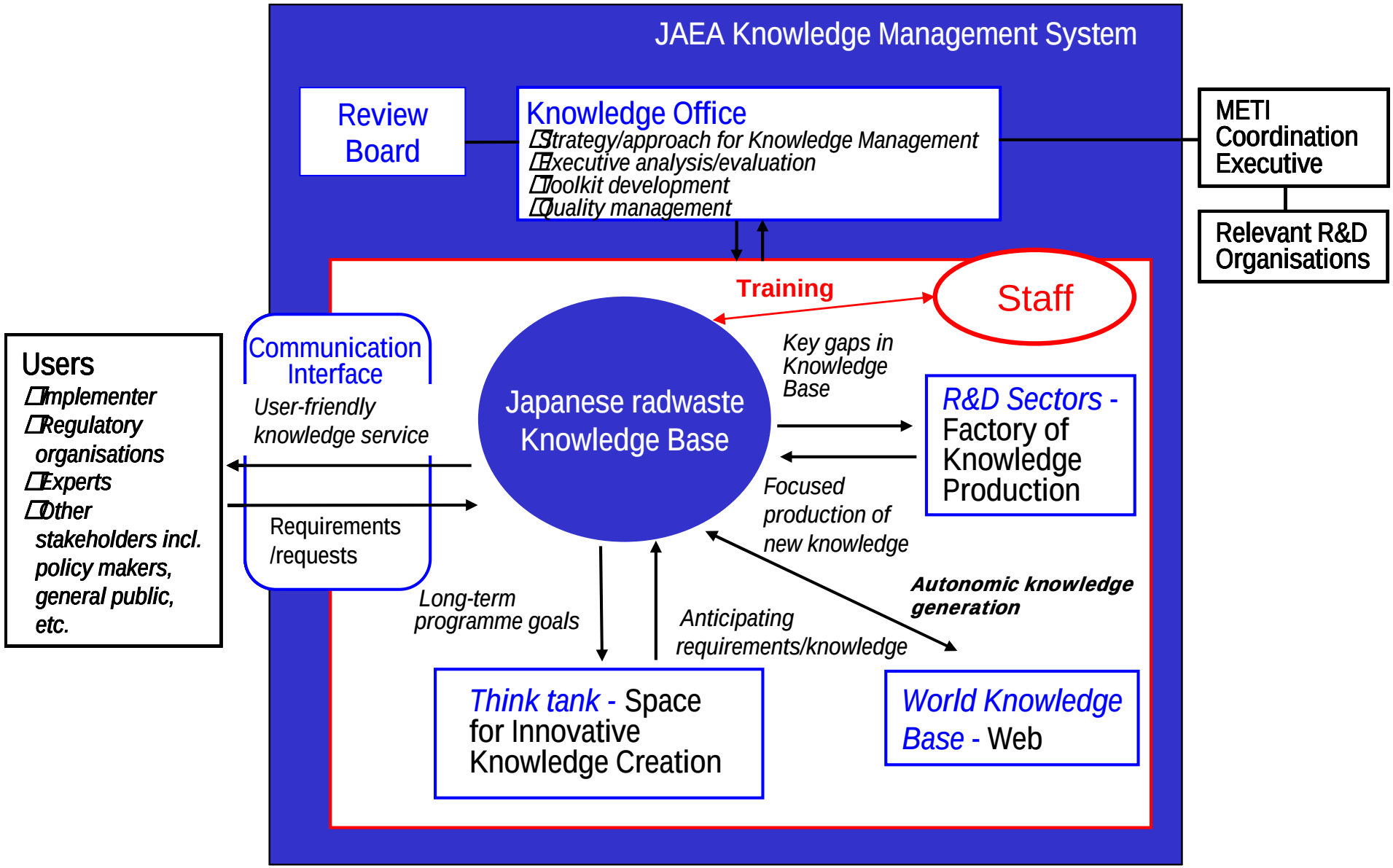


Requirements - R&D needs

Knowledge manipulation

Knowledge creation

The structure and elements of the KMS



Components of the KMS

- Structured training programme
  - Internal
  - International (e.g. ITC)
  - …
- Electronic “intelligent assistant”
- Think tank

The intelligent assistant

- 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**

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

Development strategy

- **Stepwise development of the intelligent assistant**
  - Establish nomenclature (ontology) for fundamental knowledge management
  - Establish nomenclature (ontology) for safety case development
  - Initiate development of essential components of the software in parallel (but with awareness of need to link)
  - Develop test cases to test applicability to real problems (NB output should be of value to participants)
  - Analysis of test case applications – proposals for improvements

  (iterates until applicable to entire safety case)
- **Develop and implement training plan**
- **Plan and initiate think tanks**

Conclusions

- The proposed KMS will allow JAEA to maintain a leading position in the radwaste field into the 21st century, providing an essential service to both JAEA staff and external users.
- The experience gained will be widely applicable in other areas where knowledge management will become critical over the next couple of decades.
- The “renaissance man” of 21st century radwaste will thus have a global overview provided by advanced software, databases and interfaces.
- The challenges will be great but, as this is a concern to all national waste management programmes, it is clearly an area where international collaboration could yield major dividends.